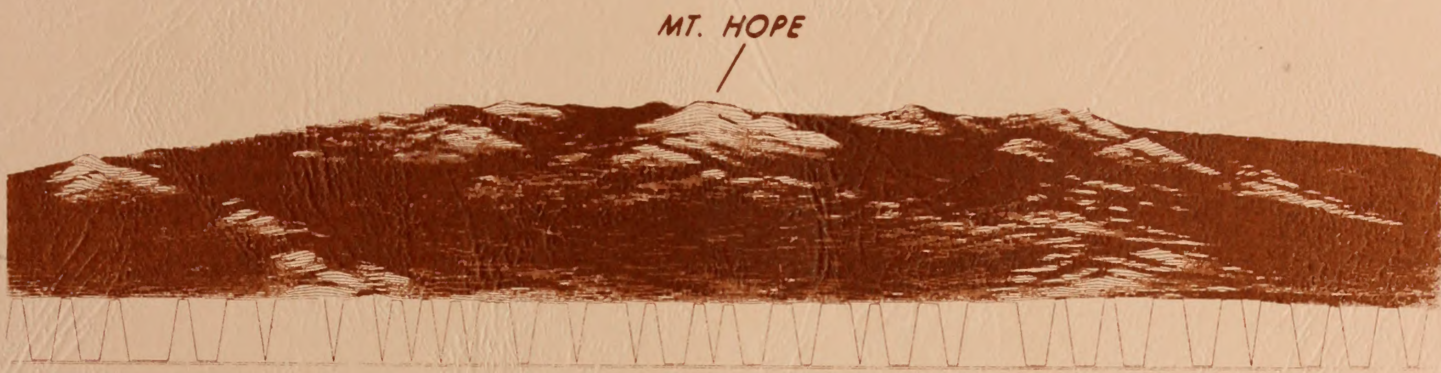
GEOLOGY AND TOPOGRAPHY

TECHNICAL REPORT NO.2

MT. HOPE MOLYBDENUM PROJECT



View from the south looking north

U.S. DEPARTMENT OF INTERIOR
BUREAU OF LAND MANAGEMENT
BATTLE MOUNTAIN, NEVADA

DECEMBER 1984

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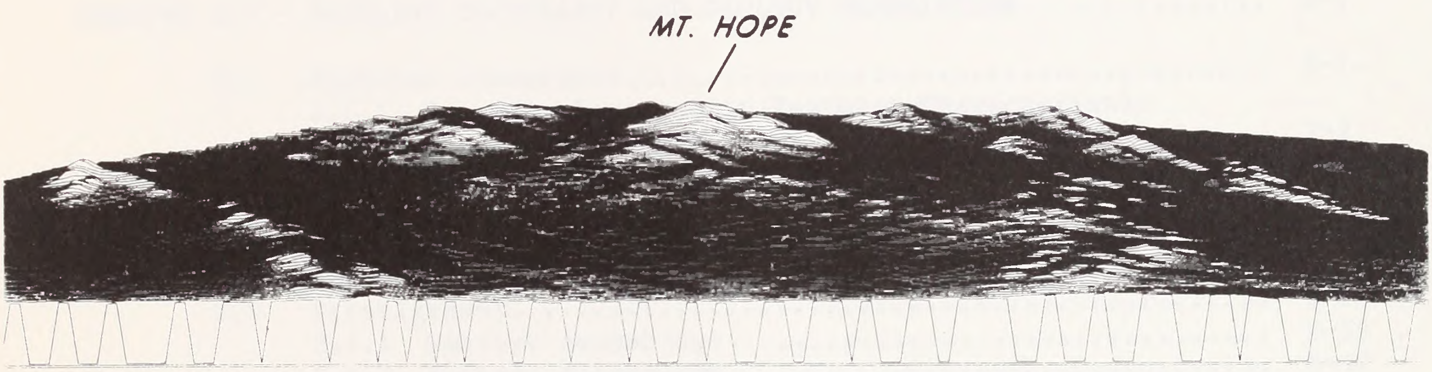

View from the south looking north

U.S. DEPARTMENT OF INTERIOR

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BATTLE MOUNTAIN, NEVADA

DECEMBER 1984

TOPOGRAPHY AND GEOLOGY

TECHNICAL REPORT NO.2

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CHAPTER 1.0

INTRODUCTION

1.1 Introduction

This technical report presents detailed information concerning the topographic and geologic resource base and any significant potential impacts to that resource base upon implementation of the proposed action and/or alternatives.

1.2 Project Description

Technical Report No.1 and Chapter 2.0 of the Mt. Hope Molybdenum Project EIS detail the proposed action and alternatives. In brief, the Mt. Hope Molybdenum Project Environmental Impact Statement (EIS) (including Technical Report Nos.1 thru 9) have been prepared in response to an EXXON Minerals Company (EXXON) proposal submitted to the Bureau of Land Management (BLM) for the purchase of public lands under Section 203 of the Federal Land Policy and Management Act (FLPMA) of 1976. Although the land purchase proposal is the action which occasions the Environmental Impact Statement (EIS) process, there are other federal decisions which must be made before EXXON may proceed. Among these are the granting of power, water line and highway relocation rights-of-way and the approval of a plan-of-operation.

The primary purpose of the proposed sale of public lands involves the planned activities of EXXON which has for some time been conducting preliminary feasibility studies assessing the development of a molybdenum deposit in the vicinity of Mt. Hope near Eureka, Nevada. As part of the EIS process, EXXON has detailed its preliminary plans concerning project development. The Mt. Hope project includes the development of an open-pit mine, non-mineralized material storage areas (2), a process plant complex of approximately 100 acres and a tailings material disposal site. As support features to the project, a proposed water line and power line would also be necessary. The proposed tailings pond site would, if implemented, require an approximate six mile relocation of an existing state highway (State Route 278).

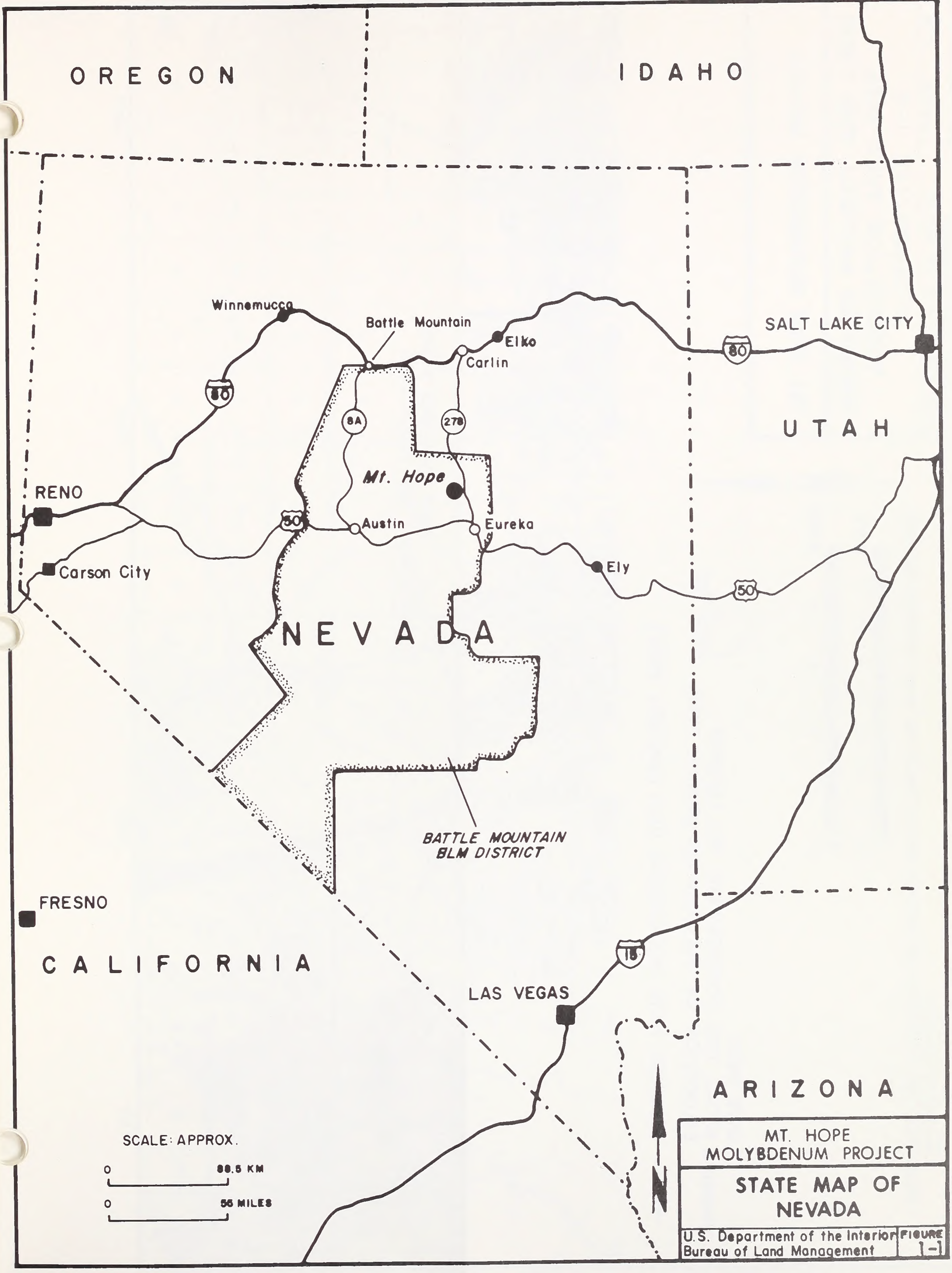
Figures 1-1 through 1-8 show project area location and depict the proposed action and alternatives (except the location of a subdivision plat). Table 1-1 outlines the components of the proposed action and alternatives, including the no action alternative.

1.3 Baseline Data Development

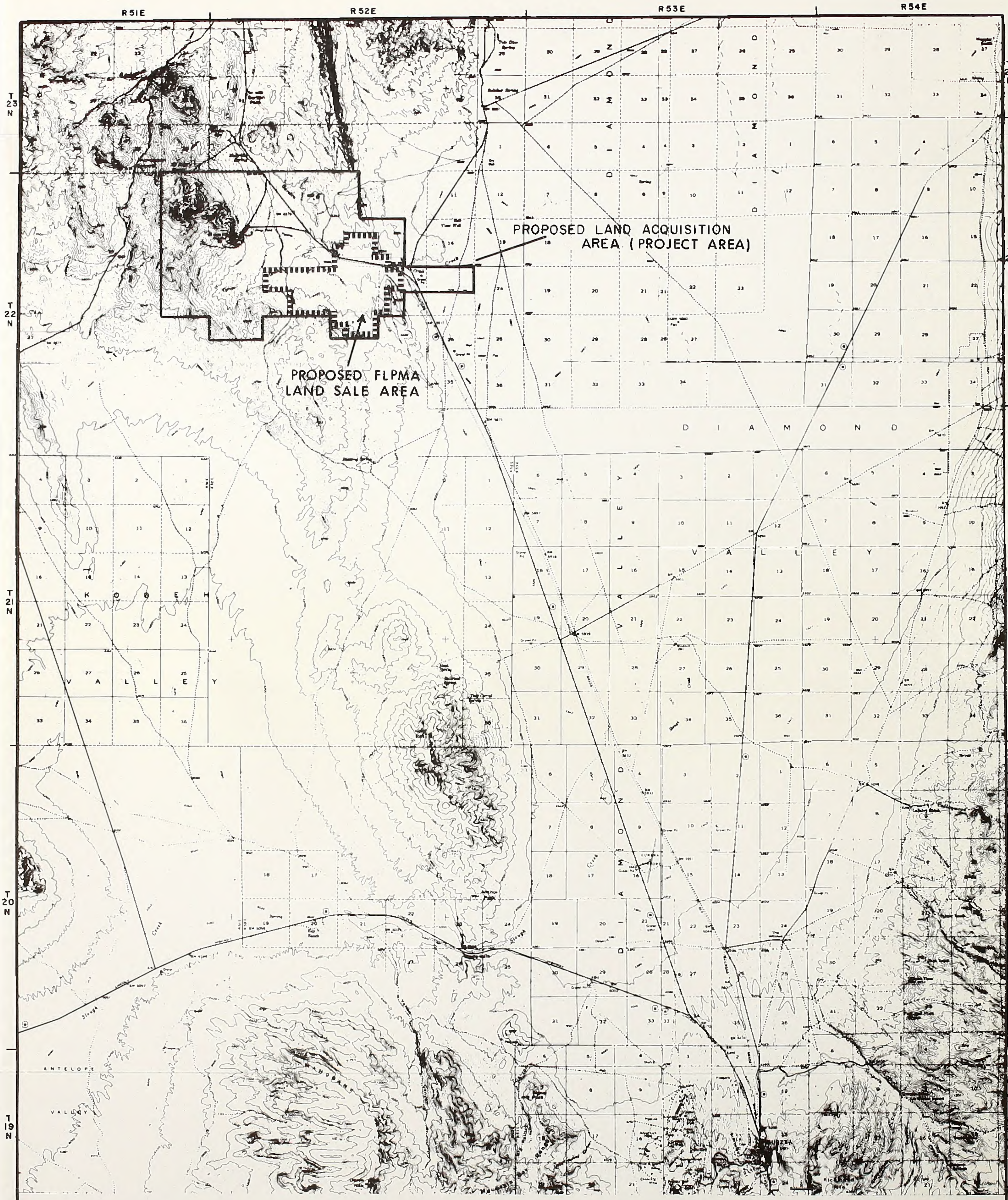
Early in the EIS process, the BLM and EXXON agreed in a Memorandum of Understanding (MOU) that the EIS process of data collection, analysis and documentation would be assisted by the involvement of an independent third party consultant, Wyatt Research and Consulting, Inc. (WRC). WRC initiated its involvement as an oversight quality assurance consultant in the development of a project source document for subsequent use in developing the Mt. Hope Molybdenum Project EIS. Entitled the Mt. Hope Molybdenum Project Environmental Impact Report (EIR), the source document included two chapters of information concerning environmental resources (baseline data and impact analyses) and prepared by WRC with assistance from the BLM and available study results of EXXON (e.g., cultural resources consultant report, geology, etc.). During the preparation of the source document and continuing throughout the EIS process, WRC has collected, reviewed and analyzed pertinent data in each of the necessary topical areas of environmental resources.

This technical report documents the majority of information gathered and analyzed that was pertinent to topographic and geologic resources. The primary sources of topographic and geologic resource information included the following:

1) U.S.G.S. 15 minute topographic quadrangle maps.
2) EXXON Mine Plan Engineering Drawings.
3) Schwarz, F.P. 1983. "Geology, Mineralization and Resources of the Mt. Hope Stockwork Molybdenum Deposit, Nevada." (EXXON Minerals Company, Houston, Texas).
4) Glass, Charles E. 1982. Seismic Hazard and Ground Response, Mt. Hope, Nevada, for EXXON Minerals Company.
5) Hunt, Charles B. 1974. Natural Regions of the United States and Canada. W.H. Freeman and Company.



OREGON
IDAHO
Winnemucca
Battle Mountain
Elko
Carlin
SALT LAKE CITY
80
UTAH
8A
278
Mt. Hope
RENO
50
Austin
Eureka
Carson City
Ely
50
NEVADA
BATTLE MOUNTAIN
BLM DISTRICT
FRESNO
CALIFORNIA
15
LAS VEGAS
ARIZONA
SCALE: APPROX.
0
88.5 KM
0
55 MILES
MT. HOPE
MOLYBDENUM PROJECT
STATE MAP OF
NEVADA
U.S. Department of the Interior
Bureau of Land Management
FIGURE
1-1



——— PROPOSED LAND ACQUISITION AREA (PROJECT AREA)

▪▪▪▪▪▪▪▪ ESTIMATION OF APPROXIMATE FEDERAL LAND POLICY AND MANAGEMENT ACT (FLPMA) SALE AREA

N

0 1 2 3 4 5 Miles

0 1 2 3 4 5 6 7 8 Km.

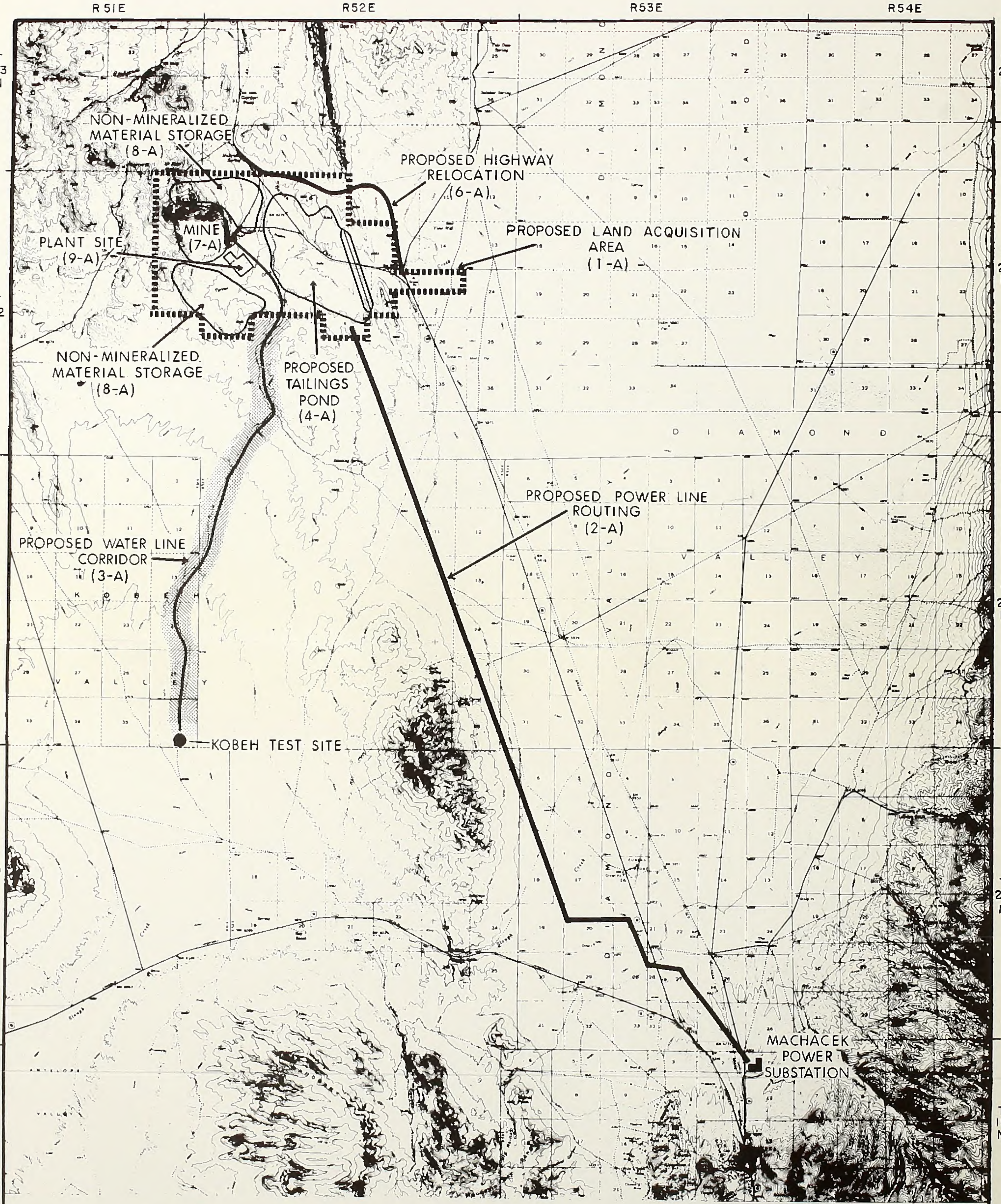
BASE: USGS TOPO QUADRANGLES, GARDEN VALLEY, WHISTLER MTN., DIAMOND SPRINGS & EUREKA, NEVADA.

MT. HOPE MOLYBDENUM PROJECT

PROPOSED PROJECT AND LAND ACQUISITION AREA MAP ALTERNATIVE I-A

U.S. Department of the Interior
Bureau of Land Management

FIGURE 1-2



PROPOSED LAND ACQUISITION AREA BOUNDARY

*NOTE: COMPONENT 5-A (HOUSING SUBDIVISION) NOT SHOWN. ALTERNATIVE 1-A (INCLUDING FLPMA LAND SALE AREA) SHOWN ON FIGURE 2-1.

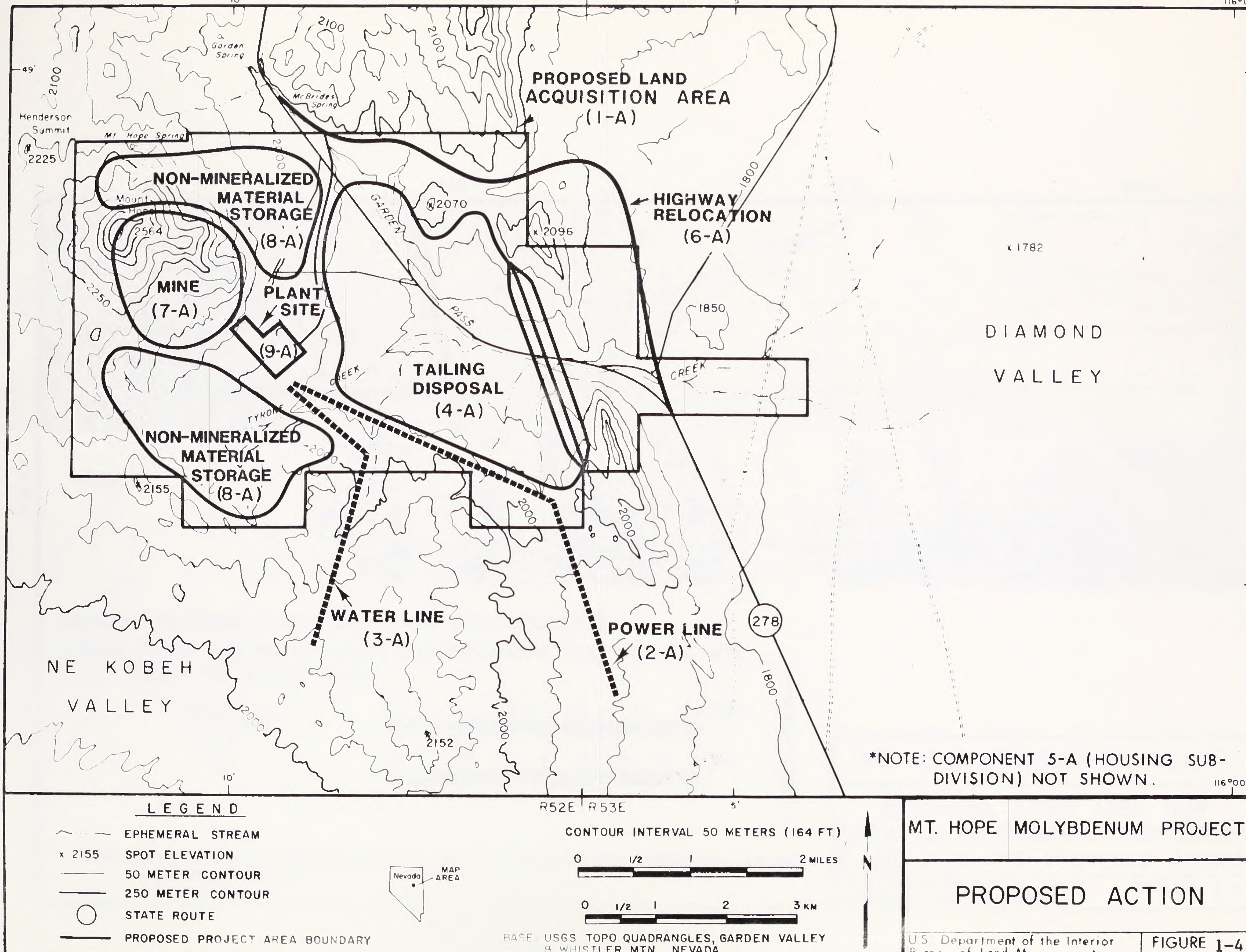
BASE: USGS TOPO QUADRANGLES, GARDEN VALLEY, WHISTLER MTN., DIAMOND SPRINGS & EUREKA, NEVADA.

MT. HOPE MOLYBDENUM PROJECT

REGIONAL STUDY AREA MAP SHOWING PROPOSED ACTION COMPONENTS

U.S. Department of the Interior
Bureau of Land Management

FIGURE 1-3

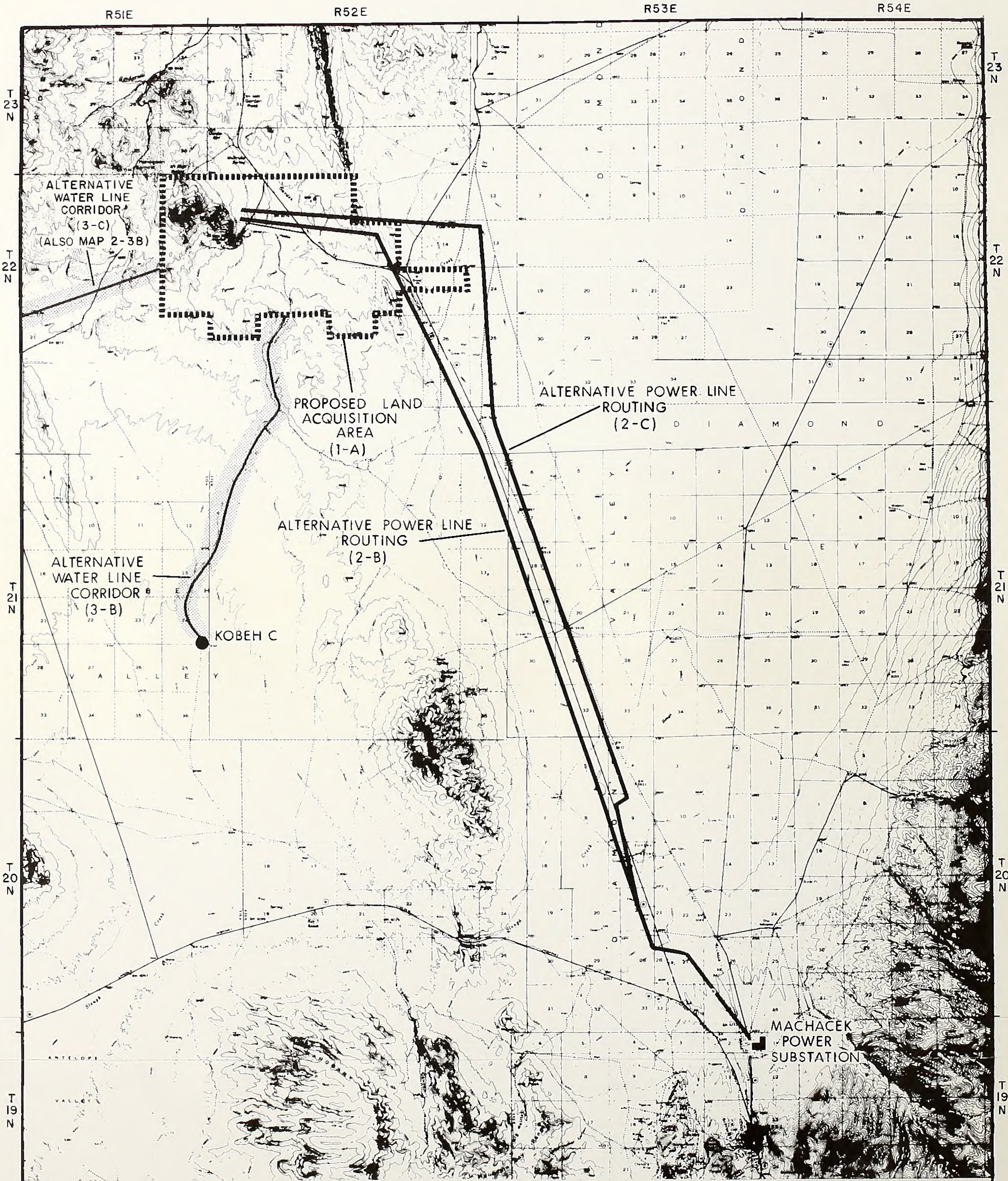


MT. HOPE MOLYBDENUM PROJECT

PROPOSED ACTION

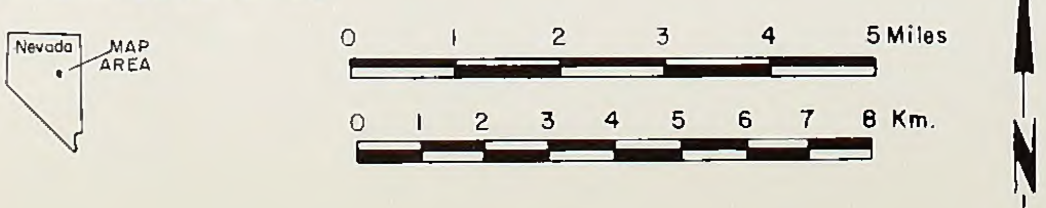
U.S. Department of the Interior
Bureau of Land Management

FIGURE 1-4



PROPOSED LAND ACQUISITION AREA BOUNDARY

*NOTE: ENTIRE EXTENT OF WATER LINE CORRIDOR 3-C NOT SHOWN, REFER TO FIGURE 2-3B



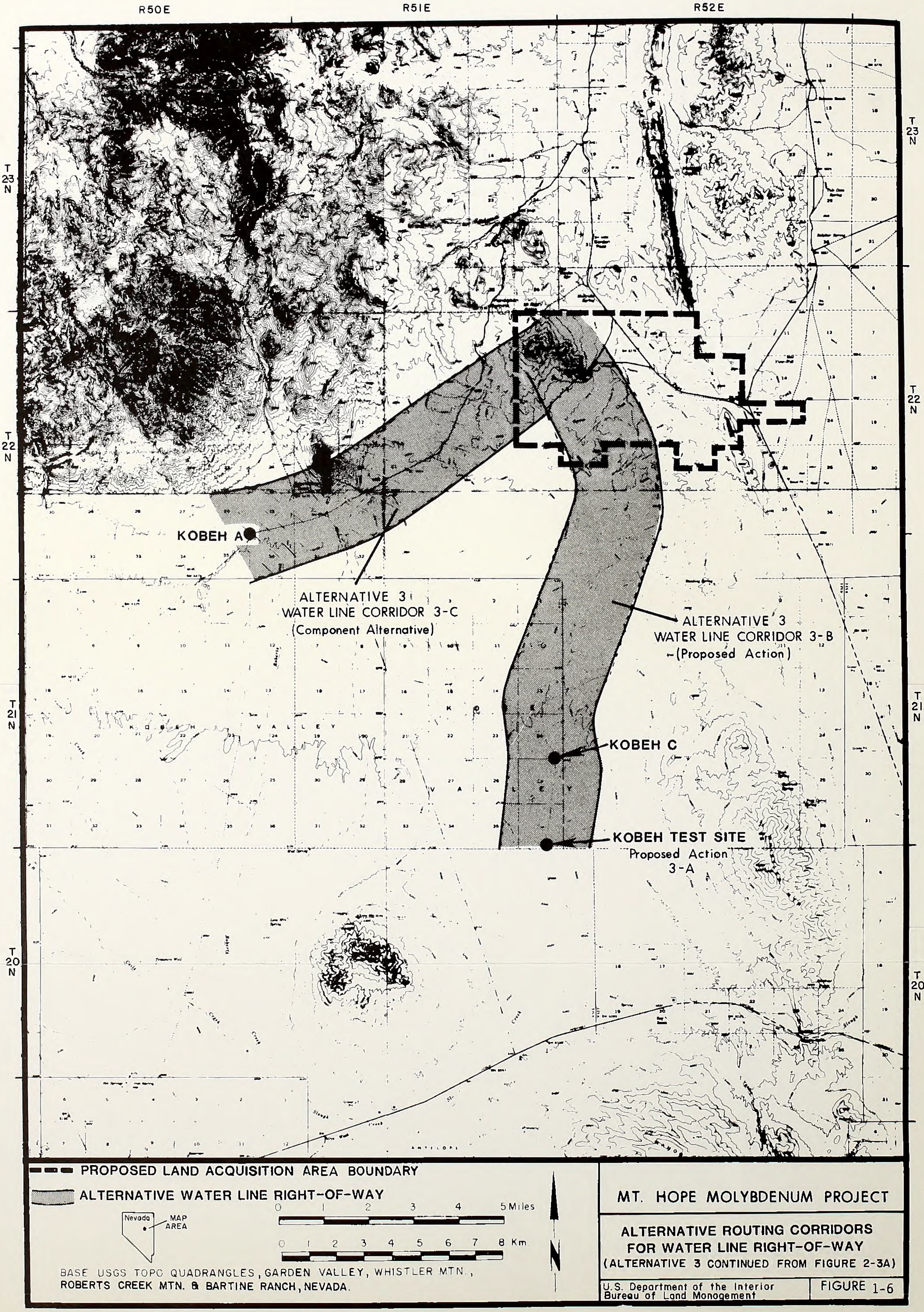
BASE: USGS TOPO QUADRANGLES, GARDEN VALLEY, WHISTLER MTN., DIAMOND SPRINGS & EUREKA, NEVADA.

MT. HOPE MOLYBDENUM PROJECT

REGIONAL STUDY AREA MAP SHOWING ALTERNATIVE COMPONENTS 2 AND 3 TO THE PROPOSED ACTION

U.S. Department of the Interior
Bureau of Land Management

FIGURE 1-5

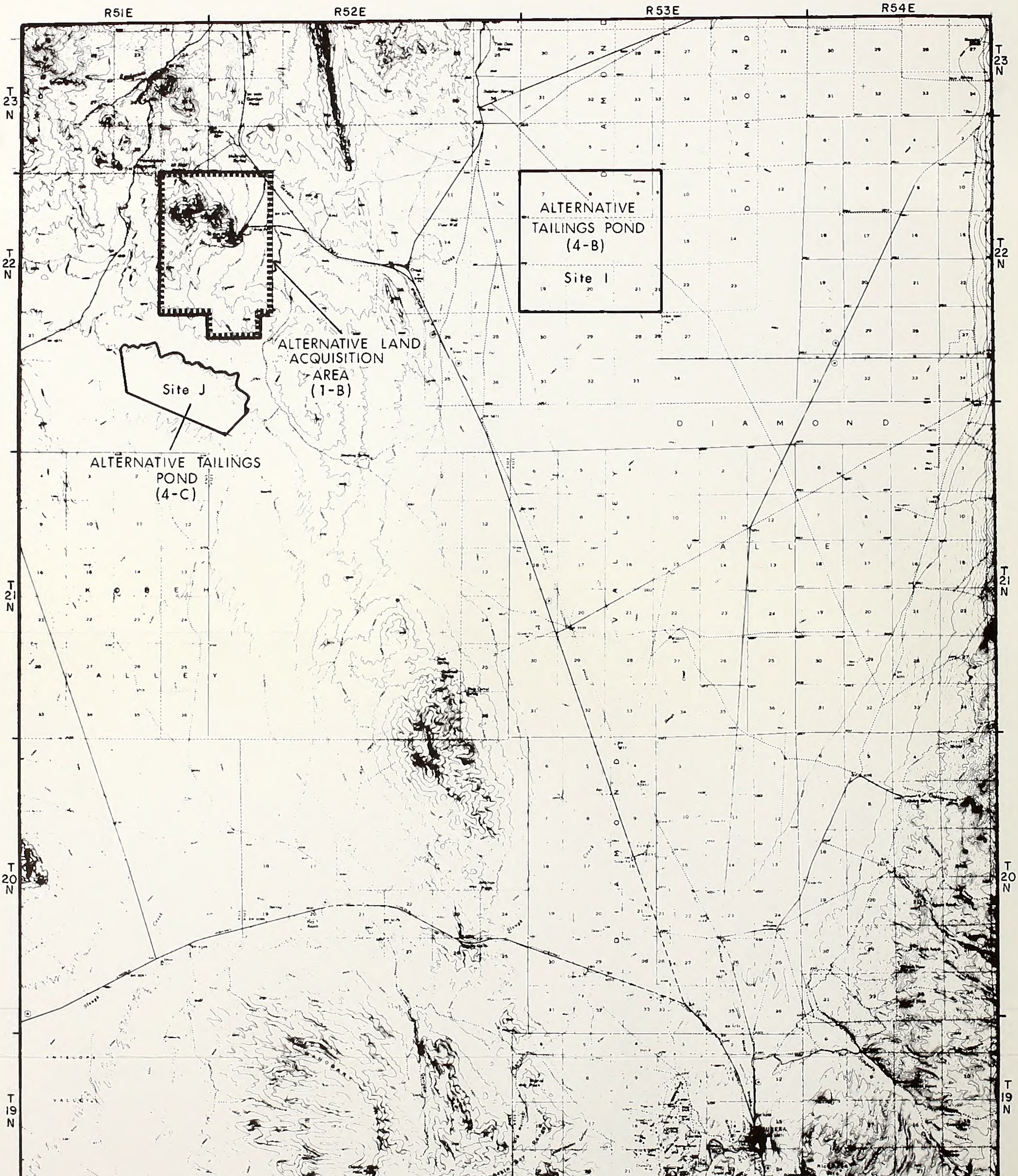


MT. HOPE MOLYBDENUM PROJECT

ALTERNATIVE ROUTING CORRIDORS FOR WATER LINE RIGHT-OF-WAY (ALTERNATIVE 3 CONTINUED FROM FIGURE 2-3A)

U.S. Department of the Interior
Bureau of Land Management

FIGURE 1-6



ALTERNATIVE LAND ACQUISITION AREA BOUNDARY

Nevada MAP AREA

0 1 2 3 4 5 Miles

0 1 2 3 4 5 6 7 8 Km.

N

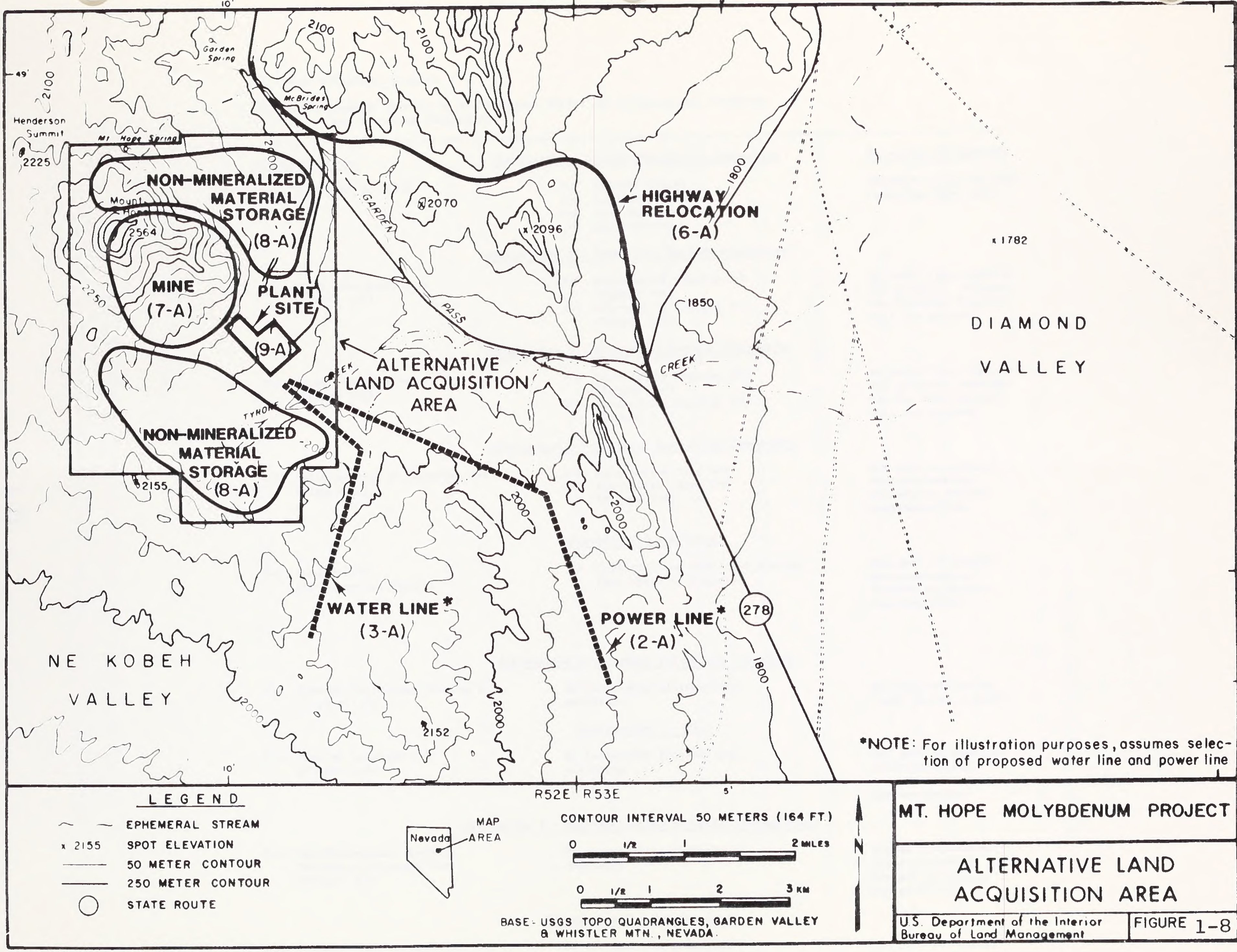
BASE: USGS TOPO QUADRANGLES, GARDEN VALLEY, WHISTLER MTN., DIAMOND SPRINGS & EUREKA, NEVADA.

MT. HOPE MOLYBDENUM PROJECT

REGIONAL STUDY AREA MAP SHOWING ALTERNATIVE COMPONENT 4 TO THE PROPOSED ACTION

U.S. Department of the Interior
Bureau of Land Management

FIGURE 1-7



MT. HOPE MOLYBDENUM PROJECT

ALTERNATIVE LAND ACQUISITION AREA

U.S. Department of the Interior
Bureau of Land Management

FIGURE 1-8

Table 1-1 Summary Details of the Proposed Action and Alternatives Including the No Action Alternative

Proposed Action	Alternative Components	No Action Alternative
	Alternative 1 - Land Acquisition Components	
1-A Land Sale by FLPMA	1-B Mineral Claims 1-C Land Use Lease 1-D Land Use Permit 1-E Land Exchange	Negative or no decision regarding land sale.
	Alternative 2 - Power Line Routing Components	
2-A Power Line Routing A (Figure 1-2)	2-B Alternative Routing 2-B (Figure 1-4) 2-C Alternative Routing 2-C (Figure 1-4)	No power line right-of way granted. Assumes the Mt. Hope Project will not proceed.
	Alternative 3 - Water Line Routing Components	
3-A Water Line Routing A (Figure 1-2)	3-B Alternative Routing 3-B (Figure 1-4) 3-C Alternative Routing 3-C (Figure 1-5)	No water line right-of-way granted. Assumes the Mt. Hope Project will not proceed.
	Alternative 4 - Tailings Pond Sites Components	
4-A Tailings Pond at Location 4-A (Figure 1-3)	4-B Alternative Site 4-B 4-C Alternative Site 4-C (Figure 1-4)	Not part of federal decision-making. Assumes no project implementation.
	Alternative 5 - Housing	
5-A Subdivision (Not shown on figure)	5-B Decentralized Workforce Housing (Not shown on figure)	Not part of federal decision-making. Assumes no project implementation.
	Alternative 6 - Highway Relocation Component	
6-A Highway Relocation Routing 6-A (Figure 1-3)	No reasonable alternatives available	No road relocation right-of-way granted.
	Alternative 7 - Mine	
7-A Mine at Location 7-A (Figure 1-3)	No reasonable alternatives available	Not part of federal decision-making. Aasumes no project implementstion.
	Alternative 8 - Non-Mineralized Material Storage Areas	
8-A Non-Mineralized Material Storsge at Location 8-A (Figure 1-3)	No reasonable alternatives available	Not part of federal decision-making. Assumes no project implementation.
	Alternative 9 - Process Plant	
9-A Process Plant st Location 9-A (Figure 1-3)	No alternatives proposed. (Proposed action is worst-case. See text).	Not part of federal decision-making. Assumes no project implementation.

6) Call and Nicholas, Inc. 1982. "Mt. Hope Pre-Mine Slope Design." Prepared for EXXON Minerals Company, Houston, Texas.

7) Merriam, C.W., and Anderson, C.A. 1942. Reconnaissance survey of the Roberts Mountains, Nevada: Geol. Soc. America Bull., v. 53, no. 12, pt. 1, p. 1675-1727.

8) Missallati, Amin A. 1973. Geology and Ore Deposits of Mt. Hope Mining District, Eureka County, Nevada. A dissertation submitted to the Dept. of Geol., Stanford University.

9) NOAA. 1973. <u>Earthquake History of the United States</u>. Publication 41-1.

10) NOAA. 1980. Supplement to Earthquake History of the United States.

11) Nevada Bureau of Mines Bull. 64. 1967. Geology and Mineral Resources of Eureka County, Nevada.

12) Nevada Bureau of Mines & Geology Special Publication MI-1982. 1983. The Nevada Mineral Industry-1982, prepared in cooperation with the U.S. Bur. of Mines.

13) Roberts, R.J., Montgomery, K.M. and Lehner, R.E. 1967. Geology and Mineral Resources of Eureka County, Nevada: Nevada Bureau of Mines, Bull. 64, (152 p.).

14) Ryall, Alan. 1977. Earthquake hazard in the Nevada region: Seismological Society of America Bulletin, v. 67, no. 2, p. 517-532.

15) Shelton, John S. 1966. <u>Geology Illustrated</u>. Ed. J. Gilluly, A.O. Woodford, W. H. Freeman and Company.

1.4 Impact Analyses Methodology

In the event of discrepancies between this Technical Report and the EIS, material presented in the EIS shall supercede that presented in this Technical Report.

1.4.1 Topographic Alterations

Topographic alterations to the existing Mt. Hope environment were determined from EXXON Mine Plan mylars. These mylars depict the planned areal extent, depth and levels for the mine pit and their corresponding topographic elevations. Other features of the mine operations, such as the tailings pond, were also shown with elevational values in order to present any topographic alteration.

The next process of the topographic alteration analysis involved computer generated figures supplied by EXXON. The figures allow for visualization in a three dimensional perspective of the existing and altered topography of Mt. Hope and the surrounding area. By digitizing the known elevational values of the existing topography versus the elevational values of the proposed action topography, the computer can generate the topographic relief as it would be seen from any desired aspect. Therefore, topographic features can be viewed in a three dimensional form from any desired direction, angle above the surface and left to right viewing angle.

The visual resources of the existing topography and those of the altered topography, in addition to the visibility of any mine components, are discussed in detail in Technical Report No.8.

1.4.2 Geologic Resources

Geologic resources were reviewed from numerous studies, reports and surveys in the Mt. Hope - Roberts Mountains - Eureka areas and in the east-central Nevada region. Geologic resources review included the EXXON Plan of Operations for the extraction of the Mt. Hope deposit. Other geologic resources reveiwed and reported in the region include various mineral deposits, geothermal energy and oil and gas.

1.4.3 Seismicity

Seismicity refers to the occurrence of seismic events, specifically earthquakes, within any given area. Earthquakes are studied and recorded in

order to determine the epicenter (exact location on the surface of the earth directly above the subterranean origin), duration, intensity, magnitude and total area affected. Intensity is the violence of earthquake motion in any part of the perciptible area of an earthquake and is based on the effects observed on people and objects. Magnitude, according to the Richter scale, is a measure of the energy release at the focus of an earthquake, as determined by shock wave amplitudes produced on a seismogram.

Seismic studies have shown that there are localized areas and large-scale regions which commonly experience earthquakes. Fault studies are also part of earthquake analysis since earth movement is known to occur along many fault-zones. Determination of the type of faults in an area, if they are presently active and the amount of displacement they show can help in assessing an areas tectonic nature (deformation of the earth's crust).

The study of the potential for seismic disturbance is a common practice in all construction and engineering fields. EXXON contracted Call and Nicholas, Inc. to determine the probability of damage to mine pit walls and to determine the slope design. Earthquake hazard potential was evaluated by Dr. Charles E. Glass of the University of Arizona for Call and Nicholas, Inc. Further analysis was performed by the geotechnical engineers of Wahler Associates in order to determine the most for withstanding a possible earthquake of a specified magnitude.

1.4.4 Mineral Processing

Geological and mineralogical data were analyzed by EXXON and for EXXON by contractors in order to determine the facilities, operations, areal extent and process design for the Mt. Hope ore. Because of the low molybdenum content in molybdenum-bearing ores, beneficiation (usually by flotation) is required. The method depends upon the type of ore, chemical and mineralogical characteristics and impurities. The overall nature of the ore body will dictate the process design and chemical beneficiation required, which will ultimately influence the tailings effluent quality which is discussed in Technical Report No.4.

1.4.5 Mining Industry

The discovery, extraction and processing of metallic minerals (mining) is reviewed because of its direct and indirect impacts upon socio-economics (public and private), population growth and particularly the State and local government revenues. The mining industry has traditionally been a prime mechanism in the economic, social and political history of Nevada.

Mining industry impacts of Eureka County is primarily restricted to fiscal impacts only. A more detailed discussion of this subject appears in Technical Report No.9. A summary of the major findings by Dobra and Atkinson (1983) of the Department of Economics and Bureau of Business and Economic Research, UNR in regards to mining industry activity is stated below:

1) Mining is an extremely significant contributor to local economics outside of the metropolitan gaming areas.
2) Mining consistently contributes a larger fraction of county payrolls than in any other employment area.
3) Direct population growth due to the tendency to bring relatively highly paid and highly skilled individuals into the workforce.
4) Mining firms operating in rural areas of the State make purchases of supplies and equipment in local and State metropolitan areas.
5) Increased expenditure of income in the local economy by mining industry employees buying consumer goods and services.
6) Mining is an important element, if not the major part, of the tax base for most of the rural counties of Nevada. Major taxes paid by mining firms are taxes on net proceeds, property taxes on mine and mill improvements and equipment, and sales and use taxes on purchases of equipment and supplies.

CHAPTER 2.0

BASELINE TOPOGRAPHY AND GEOLOGY DESCRIPTION

2.1 Regional Topography

East-central Nevada is situated within the Basin and Range Physiographic Province of Fenneman (1931). This province covers approximately 300,000 square miles and comprises roughly eight percent of the United States (Hunt, 1974). The entire State of Nevada is located within the province, in addition to portions of California, Arizona, Idaho, New Mexico, Utah and Texas. The Mt. Hope project region lies within the Great Basin Division of the Basin and Range Province which is characterized by several particularly unique topographic/geologic features (Sections 2.1.1 and 2.1.2).

The topography is dominated by north-south trending, block-faulted mountain ranges which are separated by alluvial valleys (Section 2.1.2). The mountain ranges are generally 50 to 75 miles (80 to 120 km) long and 10 to 25 miles (16 to 40 km) wide (Hunt, 1974; Erwin, 1968). The mountains rise abruptly above the valleys, with elevations of 3,000 to 5,000 feet (1,000 to 1,700 meters) greater than the valley floors. The valleys are mostly 5,000 to 6,000 ft (1,524 to 1,829 m) in altitude and are partly filled by sediment eroded from the surrounding mountain ranges. The sediment forms alluvial fans which merge and coalesce into an alluvial apron (bajada) that slopes from the base of the mountains to the alluvial floodplain or playas in the center of the valleys. Slopes on the alluvial fans are generally 5 to 15 percent with the steeper slopes closer to the mountains. The valley floors have slopes of one to five percent and the playas usually have no definable slope. Mountain slopes of 30 to 50 percent are common, although some slopes of 100 percent or greater may occur.

The physiographic features in east-central Nevada and the relative amounts of area they cover are as follows: alluvial flats, lake beds and alkali flats entail 10 percent of land area; mountains and alluvial fans, each entail 45 percent.

The existing topography has been sculptured by tectonic forces (e.g. block-faulted mountain ranges), soils types, vegetation, climate (prehistoric and recent) and stream erosion. Figure 2-1 shows the regional topography of the study area.

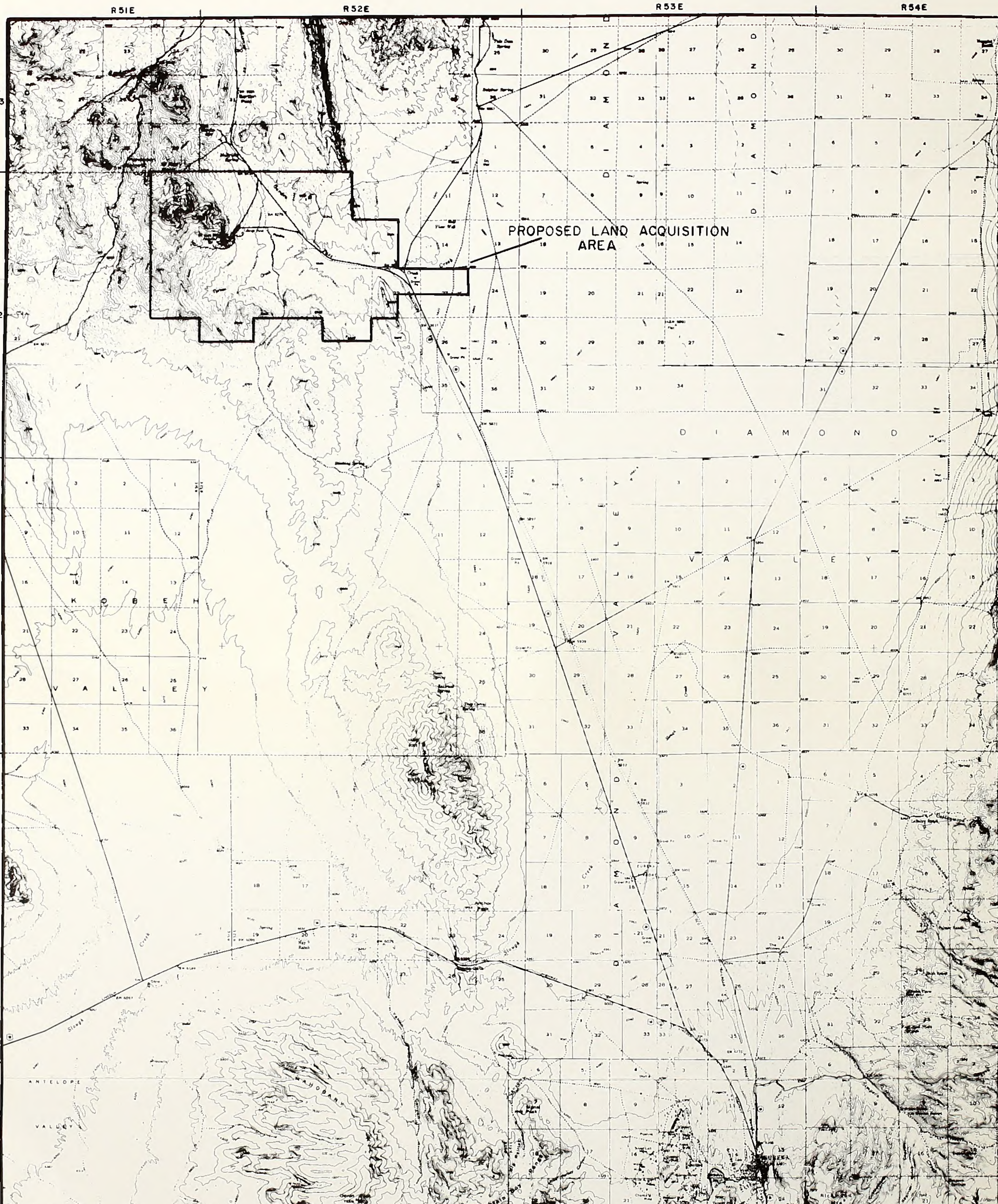
2.1.1 Specific Topographic Features Characteristic of the Province

Erosional Features. Because of the semi-arid to arid climate, vegetation is generally sparse and the dominant soil types are characteristically loose, dry and permeable. This accounts for the rapid gullying where the soil is laid bare. With little obstruction on the slopes, the proportion of surface runoff to rainfall is relatively high. Stream erosion is highest when in flood.

Streams originating in the mountains and highlands deposit significant loads of rock debris at the base of the mountains where the stream gradient abruptly changes and velocities diminish. Consequently, large alluvial fans develop.

The alluvial fans in the Basin and Range Province exhibit unique topographic features in that no single well-defined stream channel runs the course of the slopes. (Shelton, 1966) Instead, the water course is repeatedly shifted as successive channels become choked by alluviation. This tendency of division and joining of stream channels creates a braided pattern of the alluvial fan topography.

Another topographic feature of the Province is described by Shelton (1966), in which "the alluvium is broken into small steps across the head of the fan. Created by faults that parallel the base of the mountains, these fault scarps are evidence of recent tectonic uplift of the mountains relative to the valley floor. Erosion has made limited progress upon these locally uplifted areas, resulting in gullies and canyons which are narrow, shallow, very steep, devoid of channel deposits and show little branching".



—— PROPOSED LAND ACQUISITION AREA BOUNDARY

Nevada — MAP AREA

0 1 2 3 4 5 Miles

0 1 2 3 4 5 6 7 8 Km.

N

BASE: USGS TOPO QUADRANGLES, GARDEN VALLEY, WHISTLER MTN., DIAMOND SPRINGS & EUREKA, NEVADA.

MT. HOPE MOLYBDENUM PROJECT

REGIONAL TOPOGRAPHY

U.S. Department of the Interior
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FIGURE 2-1

Historical Inundation. Many of the valleys once contained lakes during the Pleistocene glacial ages. The fluctuations in lake level and eventual dessication have left various topographic features, such as ancient shorelines, as described by Shelton (1966). "These [ancient shorelines] may divide the mountain front into contrasting topographic zones. Above an upper shoreline, the mountain slopes have undergone continuous stream erosion prior to the lake's appearance. Once the lake has established itself, these streams deposit their sediment load close to the shore and in conjunction to that produced by the waves in cutting the bench or terrace. The topography of the lower slopes is generally smoother as a result of the deposits. The next zone, between shorelines, will exhibit the effects of stream erosion as a result of the lake level dropping down to the elevation of the lower shoreline. The zone below the lower shoreline has only been exposed to erosion since the later stage of the lake disappeared. The varying zones also show how streams will ultimately change the topography. The upper zone will have more canyons whereas the zone between the shorelines will be developing new gullies".

2.1.2 Mountains and Valleys of the Mt. Hope Region

The major mountain ranges in the Mt. Hope area include the Roberts Mountains (west of Mt. Hope), Sulphur Spring Range and Diamond Mountains, (both east of Mt. Hope), Simpson Park Range (southwest) and the Cortez Mountains (northwest) (Figure 2-1). Most of the mountain ranges follow a north-south linear trend, except for the Cortez and Simpson Park Mountains which have a more northeast-southwest trend. The Roberts Mountains are roughly triangular in shape and attain a maximum elevation of 10,133 feet (3,089 m). Most of the crest altitudes of the Diamond Mountains are 9,000 feet (2,744 m) or higher. Eureka township, the nearest population site to Mt. Hope, is located in a canyon on the flanks of the Diamond Mountains, at an elevation of 6,481 feet (1,976 m). Most of the crests of the Sulphur Spring Range are between 7,000 and 7,500 feet (2,134 to 2,286 m). The highest point in the area is Diamond Peak in the Diamond Mountains, reaching an elevation of 10,614 feet (3,236 m).

The major valleys in the Mt. Hope region are Diamond Valley (east of Mt. Hope), Garden Valley and Pine Valley (north), Monitor Valley, Kobeh Valley (south) and Antelope Valley (south). Diamond, Garden and Antelope Valleys are elongated in a north-south direction, whereas Pine Valley and northern Monitor Valley are elongated in a northeast-southwest direction. Kobeh Valley is roughly equidimensional in form. The lowest elevational point in the area is 5,770 feet (1,759 m) and lies in the playa of Diamond Valley. The valleys and respective areas are listed in Table 2-1.

In orientation to Mt. Hope, the Cortez Mountain Range lies farthest to the northwest and borders the western side of Pine Valley. Garden Valley, which empties into Pine Valley, lies just north of Mt. Hope and between the Roberts Mountains to the west and the Sulphur Spring Range and the Diamond Mountains farther east. South of the Roberts Mountains and west of the southern portion of the Sulphur Spring Range lies Kobeh Valley. Antelope Valley lies just south of Kobeh Valley. To the southwest of Kobeh Valley lies Monitor Valley, bordered by the Simpson Park Range to the west.

Of all the valleys, Diamond Valley is the most significant in relation to Mt. Hope. It is approximately 56 miles (90 km) long, with a maximum width of 20 miles (32 km) and an average width slightly over 12 miles (19 km). The southern end terminates in the Fish Creek Range, several miles south of Eureka. The Diamond Mountains form the east boundary of the valley and connect with the Fish Creek Range on the south. The Sulphur Spring Range, Whistler Mountain, Mahogany Hills and Mountain Boy Range form the western boundary of the valley. The valley is closed at the north end by the Diamond Hills which connect the Diamond Mountains with the Sulphur Spring Range in the vicinity of Bailey Mountain.

During the Pleistocene age and possibly earlier, a large lake occupied Diamond Valley. The prior existence of this lake and the fluctuations of the lake level have left noticeable features in the topography of the area. Numerous ancient shorelines, terraces, bars, cliffs, spits and beaches are found in the valley.

Mt. Hope Molybdenum Project

Table 2-1 Valleys and Approximate Areas in the Mt. Hope Region

Valley	Square Miles	Square Kilometers	Acreage
Monitor	1,060	2745	678,400
Kobeh	875	2266	560,000
Pine	730	1891	467,200
Diamond	700	1813	448,000
Garden	493	1277	315,520
Antelope	456	1181	291,840
Stevens Basin	18	47	11,520

Source: WRC EIS Team 1983

The northern floor of Diamond Valley is occupied by a large playa, or alkali flat, and is the lowest elevational point of the valley at 5,770 feet (1,759 m). The surface of the playa is nearly flat and covers an area of approximately 50,000 acres. Low dunes form locally along the edge of the playa. The floor of the valley rises southward, toward Eureka, and reaches an altitude of 5,945 feet (1,812 m) at the Eureka Airport. The average gradient is about nine feet per mile (1.7 m per km).

The alluvial apron of Diamond Valley has a slope which decreases from about 100 feet per mile (19m per kilometer) near the mountain fronts, to only a few feet per mile near the playa. Local relief may be as much as 25 feet (8 m), due principally to stream entrenchment on the higher slopes and to bars, spits and beach deposits on intermediate and lower slopes.

At the north end of the valley a series of Pleistocene beaches, terraces, cliffs and spits are prominent between altitudes of 5,860 and 6,040 feet (1,786 and 1,841 m). The southern part of the valley floor has been somewhat modified by stream channels and Pleistocene lake features.

Devil's Gate Gap (el. 5,990 feet (1,826 m)), between Whistler Mountain and the Mahogany Hills, is a topographic low which permits occasional drainage, both surface and subsurface via slough creeks, into Diamond Valley from Antelope, Kobeh and Monitor Valleys.

Railroad Pass (el. 6,040 ft. (1,841 m)) in the northeast part of the valley was an outlet for drainage from Diamond Valley into Huntington Valley during Pleistocene time. The altitude of the divide in Railroad Pass is now about 125 feet (38 m) above the playa in the valley.

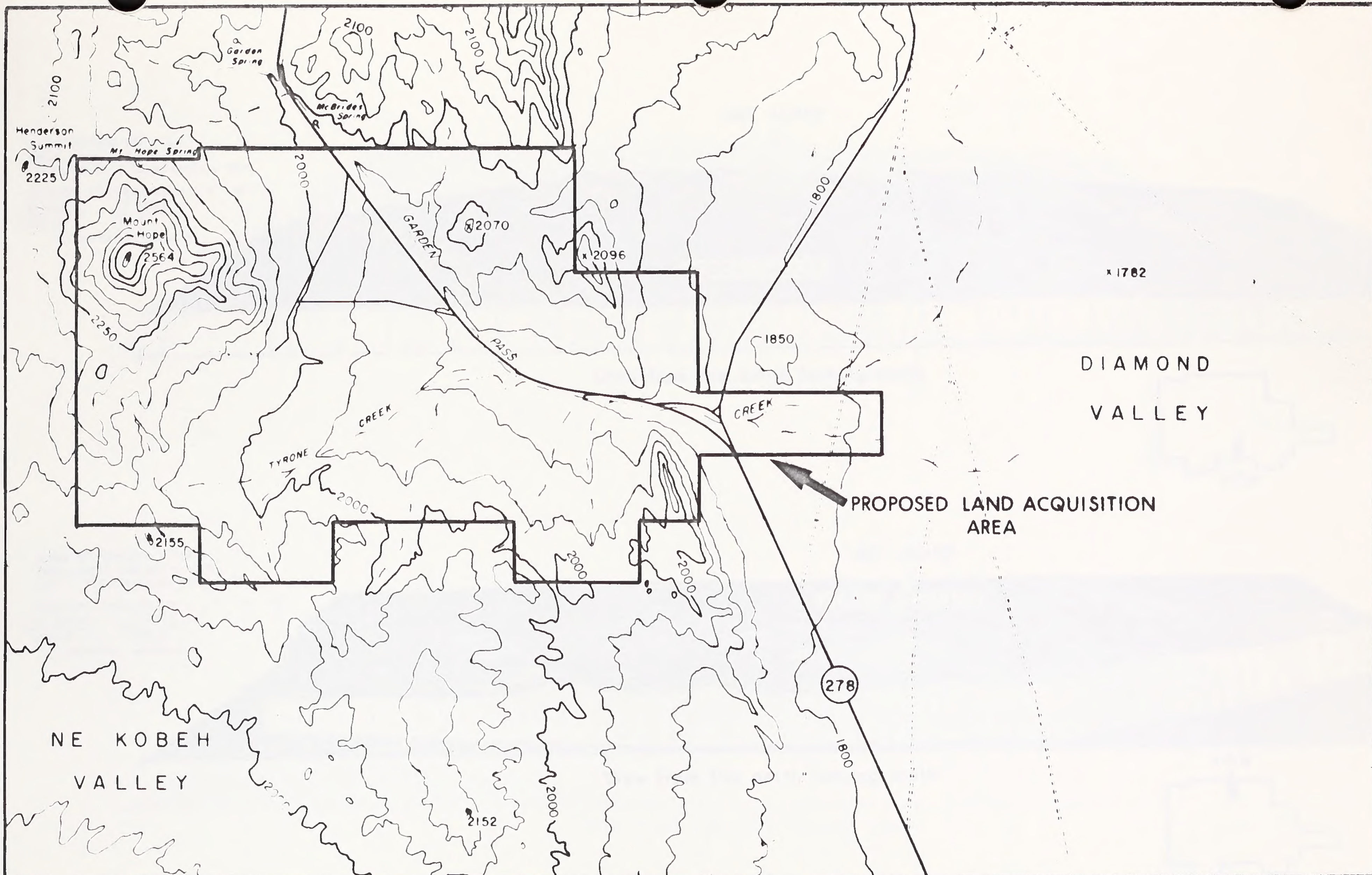
None of the valleys previously discussed contain perennial lakes. The only perennial stream in the Mt. Hope area is a portion of a spring-fed tributary of Henderson Creek. This tributary is approximately 2.8 miles (4.5 km) northwest of Mt. Hope, beyond Garden Pass (el. 6,685 ft (2,038 m)) and within Garden Valley itself.

2.2 Topography of the Mt. Hope Site and Immediate Vicinity

Mt. Hope reaches an elevation of 8,411 feet (2,564 m) and lies in the low foothills of the southeast flank of the Roberts Mountains. Areas to the immediate northeast, east and southeast gently slope to elevations of from 6,800 to 6,300 ft (2,073 to 1,920 m) (see Figure 2-2). The north northeast area would accommodate one of the proposed non-mineralized storage areas. A low lying area or hollow lies between Mt. Hope and the Sulphur Spring Range to the east. This hollow, where the proposed mine/mill facilities and proposed tailings pond Site 4-A would be situated, descends to an elevation of 6,080 ft (1,854 m). Also located within the hollow would be portions of the proposed power line routing (2-A) or alternative power line right-of-way routes 2-B and 2-C; portions of alternative water line corridor 3-B and 3-C, in addition to a portion of the proposed water line corridor (3-A). A three dimensional perspective of the existing topography at Mt. Hope is shown in Figures 2-3 and 2-4.

The Mt. Hope proposed acquisition area is somewhat encircled because of the surrounding mountain ranges and foothills. A discussion of this situation follows.

To the north and northeast, and standing barrier to Garden Valley, are foothills with several summits of between 7,100 to 7,400 feet (2,165 to 2,256 m) which join Sulphur Spring Range to the east. The proposed relocation of State Route 278 lies within this series of foothills, along the lower elevations of 6,400 to 6,800 ft (1,950 to 2,073 m), before crossing over the southern portion of the Sulphur Spring Range. Alternative power line right-of-way routes 2-B and 2-C also traverse the same vicinity of the Sulphur Spring Range. On the west, Mt. Hope is bounded by the Roberts Mountains, which are joined to the foothills south of Mt. Hope. The second proposed non-mineralized material storage area would be located directly south of Mt. Hope. These foothills have numerous summits of between 6,800 to 7,000 ft (2,073 to 2,134 m) and merge eastward into the southern tip of the Sulphur Spring Range. West of this junction, an elevational ridge connects with the hills south of Mt. Hope. This ridge has summits of from 6,800 to 7,200 ft (2,073 to 2,195 m), extends southeast to Whistler Mountain and effectively



LEGEND

⌒ ⌒	EPHEMERAL STREAM
x 2155	SPOT ELEVATION
——	50 METER CONTOUR
——	250 METER CONTOUR
○	STATE ROUTE
——	PROPOSED LAND ACQUISITION AREA BOUNDARY

Nevada — MAP AREA

CONTOUR INTERVAL 50 METERS (164 FT)

0 1/2 1 2 MILES

0 1/2 1 2 3 KM

N

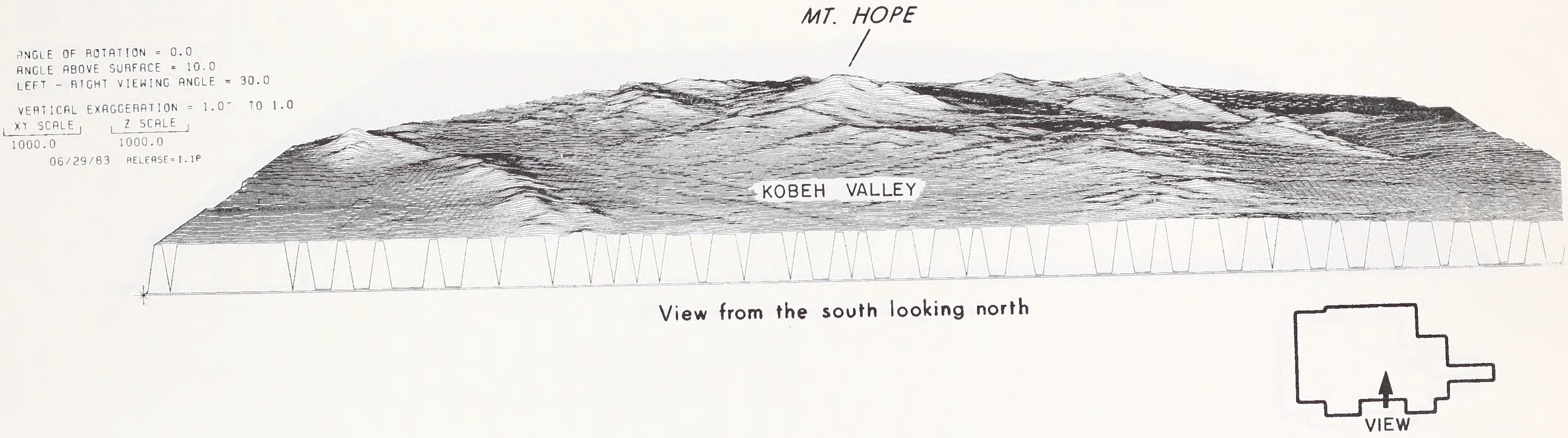
BASE: USGS TOPO QUADRANGLES, GARDEN VALLEY & WHISTLER MTN., NEVADA.

MT. HOPE MOLYBDENUM PROJECT

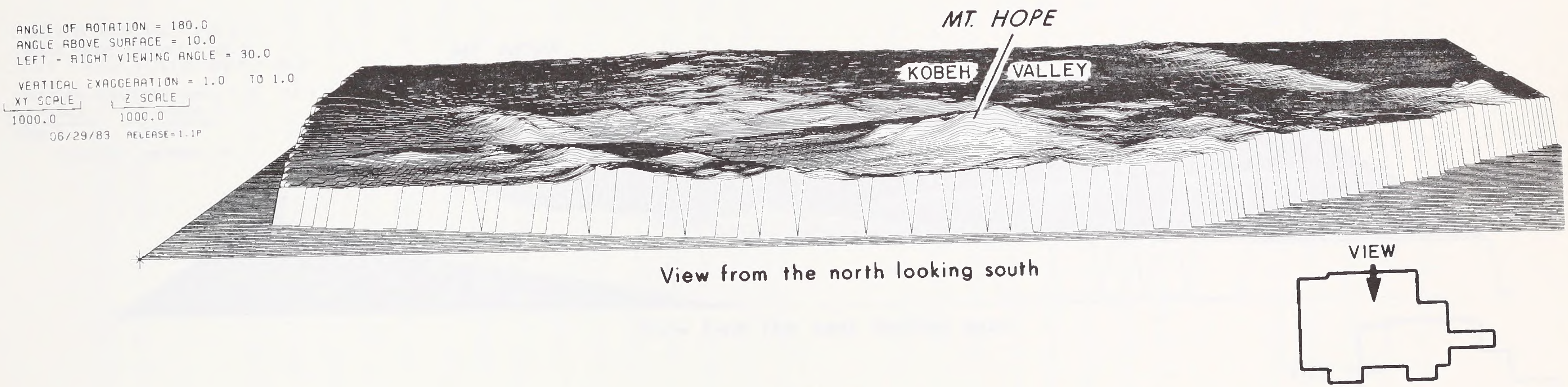
MT. HOPE SITE TOPOGRAPHY

U.S. Department of the Interior Bureau of Land Management

FIGURE 2-2



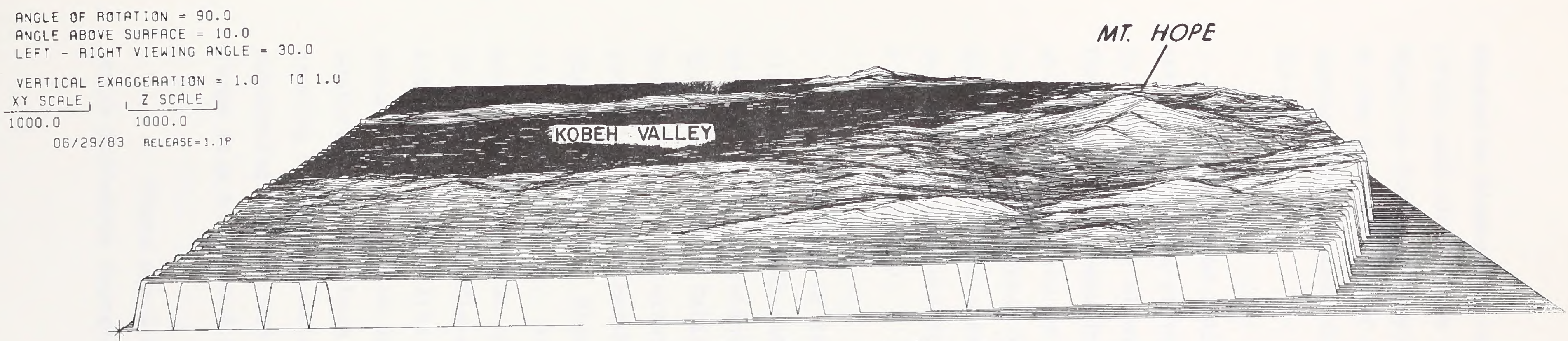
View from the south looking north



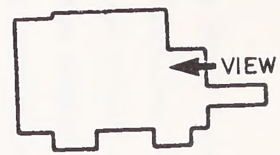
View from the north looking south

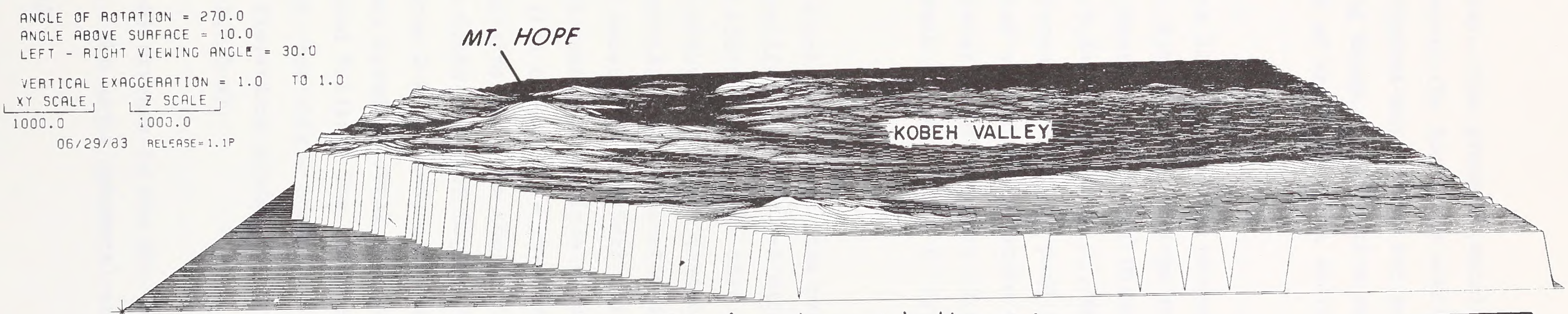
FIG. 2-3

PERSPECTIVE OF THE EXISTING TOPOGRAPHY OF MT. HOPE



View from the east looking west





View from the west looking east

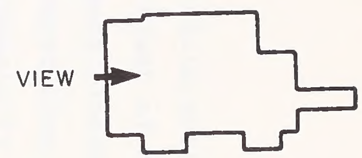


FIG. 2-4
PERSPECTIVE OF THE EXISTING TOPOGRAPHY OF MT. HOPE

separates Diamond Valley from Kobeh Valley. The proposed water line corridor (3-A), and alternative corridor 3-B traverse the foothills southeast of Mt. Hope, as does the proposed power line right-of-way (2-A), but much closer to the southern tip of the Sulphur Spring Range. Alternative water line corridor 3-C crosses the foothills south of Mt. Hope, in a southwesterly direction.

Proposed tailings pond Site 4-A lies within the proposed acquisition area and has been previously described. Alternative tailings pond 4-B (Site I) is located on the alluvial flats in the western portion of Diamond Valley. The elevation ranges from approximately 5,843 to 5,857 ft (1,780 m to 1,785 m) with slopes of zero to two percent. Alternative tailings pond 4-B (Site J) is located on a broad alluvial fan located on the northeastern edge of Kobeh Valley. The area has a maximum elevation of 6,600 ft (2,019 m), slopes gently to moderately to the southwest where the elevation is approximately 6,400 ft (1,950 m).

Outside of the proposed land acquisition area, the proposed water line corridor (3-A) and alternative water line corridor 3-B extend south along the western alluvial apron of the elevational ridge that separates Diamond and Kobeh Valley, cross a broad alluvial fan and descend into Kobeh Valley. Alternative water line corridor 3-B terminates approximately two miles farther north of the proposed water line corridor and at a slightly higher elevation. Elevations along both routes range from 6,080 to 6,760 ft (1,853 to 2,060 m). Alternative water line corridor 3-C extends southwest across the foothills of the Roberts Mountains and into the northern portion of Kobeh Valley. Elevations range from 6,080 to 7,200 ft (1,854 to 2,195 m). Alternative power line right-of-way routes 2-B and 2-C, once outside the proposed acquisition area, proceed across broad alluvial fans and into the southwest and southern portions of Diamond Valley. The proposed power line routing (2-A) also enters Diamond Valley, but skirts the elevational ridge separating Diamond and Kobeh valleys. Elevations along all three routes range from 6,790 to 5,820 ft (2,096 to 1,775 m).

There are a number of ephemeral streams in the Mt. Hope area which influence topography via erosion. The major ephemeral streams are

Garden Pass Creek, Tyrone Creek and two unnamed streams to the west and southwest of Mt. Hope which drain into northeast Kobeh Valley. Numerous gullies have been incised by small ephemeral streams in the northeast and northcentral portions of Kobeh Valley and the eastern flank of the Sulphur Spring Range.

Tyrone Creek merges into Central Garden Pass Creek, where the topography is relatively flat and Garden Pass Creek exists as a deeply incised meandering channel. An erosional gap has been cut into the Sulphur Spring Range east of Mt. Hope through which Garden Pass Creek empties into Diamond Valley. The benchmark elevation at the gap is 5,969 feet (1,820 m). At this point, the entire stream channel is approximately 45 feet wide (13.7 m) and incised 5 feet (1.5 m) below the surface. East of the erosional gap, Garden Pass Creek develops a flatter channel and then a more braided pattern until it is lost upon the alluvial apron of Diamond Valley.

2.3 Regional Geology

The regional geologic setting of east-central Nevada is characteristic of the Basin and Range Physiographic Province in which it is located. This province consists of north-south trending mountain ranges formed by normal block faulting and separated by alluvium-filled valleys. The primary physiographic features adjoining the Mt. Hope area are evidence of this faulting and include the Roberts Mountains and the Sulphur Spring Range. The Mt. Hope area appears as a compact cluster of hills belonging to the southeastern flank of the Roberts Mountains and joining the Sulphur Spring Range to the east. Garden Valley lies between these two mountain ranges and Diamond Valley lies to the east of the Sulphur Spring Range. South of the Roberts Mountains and west of the Sulphur Spring Range's southern exposure lies Kobeh Valley.

The mountain ranges are composed primarily of a thick sequence of complexly faulted and folded Paleozoic sedimentary rocks, mostly carbonates, as well as some minor volcanics, which were deposited in the Cordilleran Geosyncline. These rocks have been identified as calcareous and sandy limestone, dolomite, chert, shale, siliceous shale, quartzite, siltstone, conglomerate and some andesitic volcanic rock. In addition to Paleozoic rocks, the mountain

ranges contain minor amounts of Mesozoic and Cenozoic rocks. Some late Mesozoic igneous intrusive and volcanic rocks are found, but Tertiary volcanic and igneous intrusive rocks predominate. These Tertiary rocks are mostly intrusive and extrusive rhyolites and rhyolitic breccias.

The valleys (basins) have been partly filled with unconsolidated and semi-consolidated alluvium composed of clay, silt, sand and gravel derived from the surrounding mountains and adjacent regions. They also contain fresh water limestone, evaporites and pyroclastics deposited under lacustrine and subaerial conditions.

A typical valley is divided into two major parts: the alluvial apron and the playa flat. The alluvial apron is the area of intermediate slope at the base of the mountain ranges. The apron is composed of coalescing older and more recent alluvial fans of Tertiary - Quaternary age. Pleistocene lake features are commonly developed in the form of ancient beaches and shorelines on the alluvial apron.

The playa flat occupies the floor of the valley. Playas often contain lacustrine deposits and fine-grained wind-blown material forming low dunes along the playa margins.

Beneath the alluvium the valleys contain bedrock, which includes rocks of Paleozoic age, principally dolomite and limestone with lesser amounts of shale, sandstone (or quartzite), and conglomerate; fresh-water limestone, and clastics of Early Cretaceous age; intrusive rocks of Late Cretaceous or Early Tertiary age; and lavas and associated pyroclastics of Tertiary age. These are the same rocks that crop out in the adjacent mountain ranges.

2.4 Stratigraphy

The Mt. Hope area and adjacent regions contain rocks ranging in age from Precambrian to Recent. Precambrian siltstones and carbonates are exposed at Lone Mountain, where Precambrian sedimentary rocks are overthrust over Cambrian sedimentary rocks (Erwin 1968).

The Paleozoic rocks can be divided into Western, Eastern and Overlap assemblages.

2.4.1 Western Assemblage

This thick Paleozoic sequence of siliceous sediments and volcanic rocks (Figure 2-5) was deposited in a deep-water, eugeosynclinal environment. It included the Ordovician Vinini and Valmy Formations, as well as a group of younger, undivided, sedimentary rocks (Roberts, 1958 and 1967). Although Roberts (1958) estimated the Western Assemblage to be in excess of 50,000 feet (15,250 m) thick, the sequence is probably much thinner in the Roberts Mountains area due to thrusting, uplift and erosion. Near the proposed mine site, exploration holes drilled by Exxon to depths greater than 2,600 feet (793 m) have not fully penetrated the Western Assemblage. Therefore, at present, the exact thickness remains unknown.

The Western Assemblage rocks consist mainly of shale, siliceous shale, chert, quartzite and siltstone with minor amounts of limestone and andesitic volcanic rocks which range in age from Ordovician to Late Devonian (Roberts, 1967). In the Roberts Mountains area, the Western Assemblage is represented entirely by the Ordovician Vinini Formation. The Vinini forms the basal unit of the Roberts Mountains thrust plate. Merriam and Anderson (1942) recognized two units in the Vinini Formation. Regionally, the lower part of the Vinini consists of quartzite, sandstone, siltstone and andesitic flows and tuffs; the upper part comprises a succession of bedded cherts and shales.

The Vinini Formation exposed in the Mt. Hope mine area also contains a lower and upper part. The Lower Vinini consists of a basal unit of silty argillite, shale and chert, a middle unit of shale with calcareous sandstone lenses, and lava flows and tuff near the top. The Upper Vinini consists primarily of bedded cherts and organic shales and is not of widespread occurrence in the mine area.

Although data are lacking, structural and stratigraphic relationships suggest that in certain areas of the surrounding valleys, the Vinini Formation underlies the alluvial material.

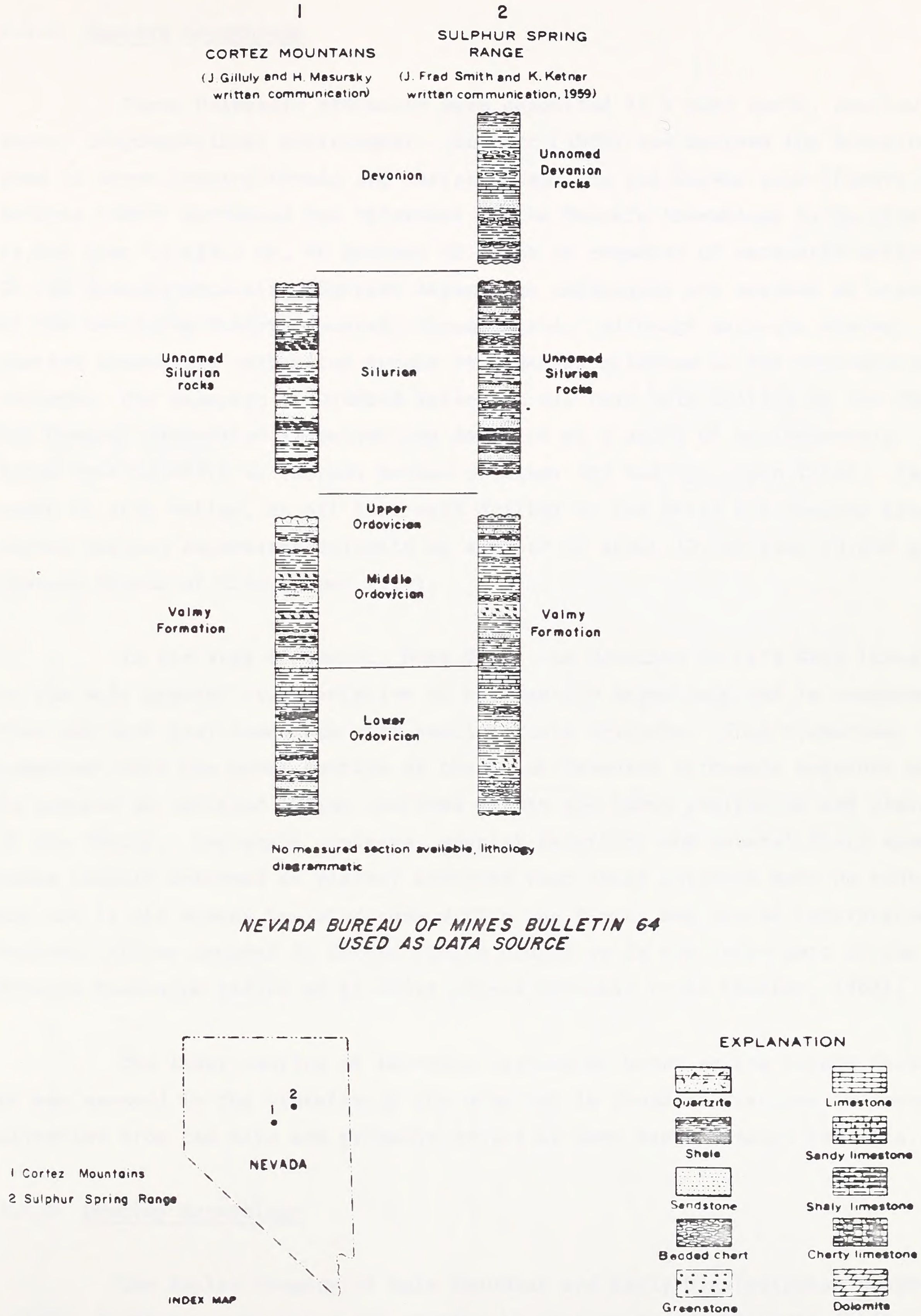


FIGURE 2-5
STRATIGRAPHIC COLUMNS OF THE WESTERN ASSEMBLAGE ROCKS
IN EAST-CENTRAL NEVADA

2.4.2 Eastern Assemblage

These Paleozoic sediments were deposited in a near shore, shallow water, miogeosynclinal environment. Stewart (1980) has defined the depositional area to cover eastern Nevada and western Utah. In the Eureka area (Figure 2-6), Roberts (1967) estimated the thickness of the Eastern Assemblage to be about 14,500 feet (4,422.5 m), 90 percent of which is composed of carbonate material. In the Roberts Mountains, Eastern Assemblage carbonates are exposed as windows in the overlying Roberts Mountain thrust plate. Although data are scarce, Eastern Assemblage carbonates appear to underlie alluvium in the surrounding valleys. For example, in Diamond Valley an oil test hole drilled by the Shell Oil Company penetrated limestone and dolomite at a depth of approximately 7,500 feet (2,287.5 m) (Nevada Bureau of Mines and Geology, open file). Farther north in Pine Valley, an oil test well drilled by the Getty Oil Company intersected Eastern Assemblage dolomite at a depth of about 10,000 feet (3,050 m) (Nevada Bureau of Mines, open file).

In the area of the Mt. Hope Mine, the Devonian Devil's Gate Limestone is the sole exposed representative of the Eastern Assemblage and is composed of blue and dark gray limestone with small calcite veinlets. This formation comprises only the upper section of the thick Devonian carbonate sequence and is exposed as isolated bodies confined within the lower argillites and shales of the Vinini. Low angle contacts, spatial relations and general field appearances (highly deformed in places) indicate that these outcrops have no roots and are in all senses isolated pods within the Vinini and can be interpreted as tectonic slices bounded by thrust faults caught up in the lower part of the Roberts Mountains thrust as it moved across Devonian rocks (Walker, 1962).

The lower section of Devonian carbonates known as the Nevada Formation is not exposed in the vicinity of the mine but is found at distance in every direction from the site and probably occurs at some depth beneath the site.

2.4.3 Overlap Assemblage

The Antler Orogeny of Late Devonian and Early Mississippian caused uplift, folding and faulting and erosion in western Nevada (Roberts 1967). The

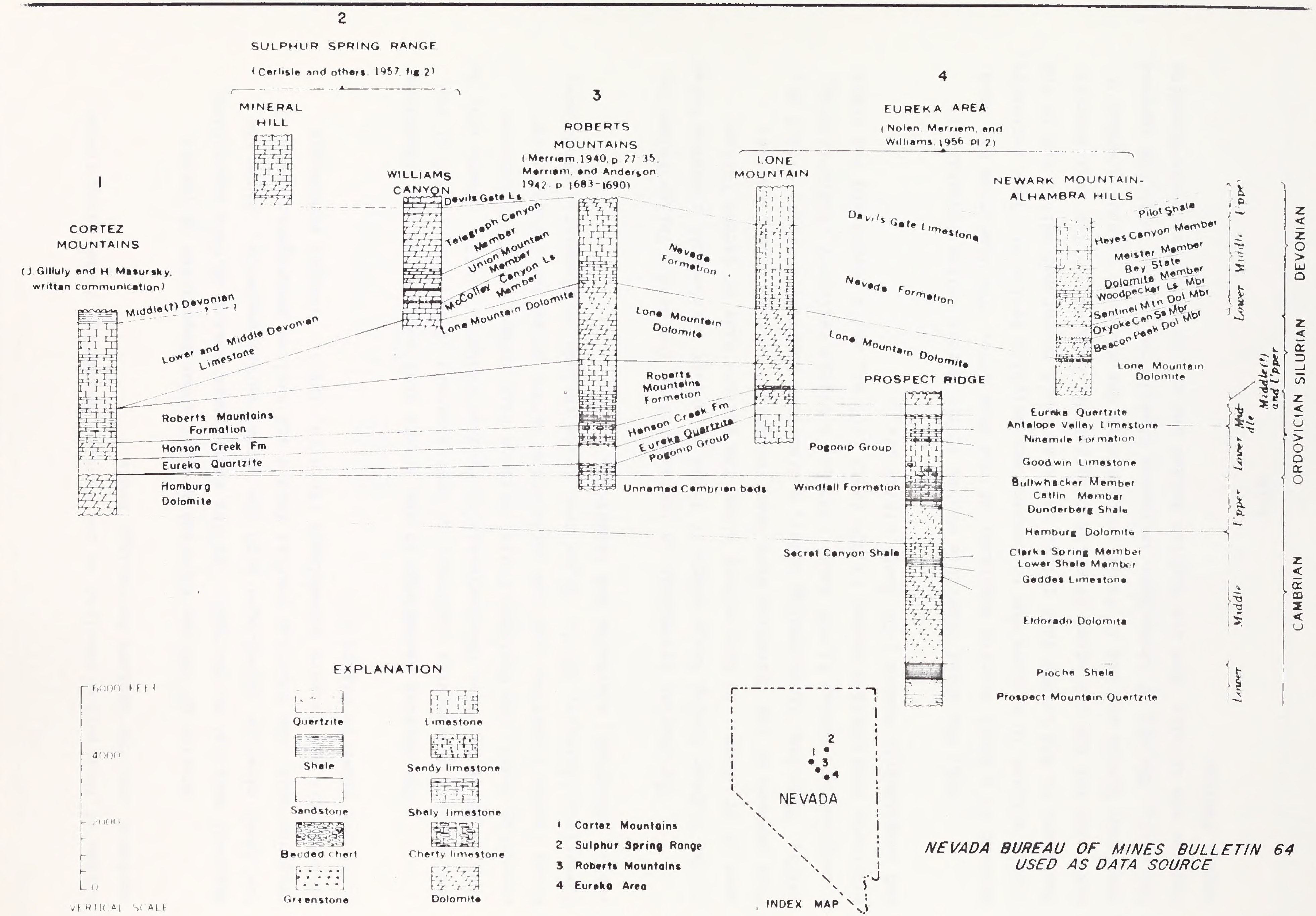


FIGURE 2-6
STRATIGRAPHIC COLUMNS OF THE EASTERN ASSEMBLAGE ROCKS IN EAST-CENTRAL NEVADA

climax of this period resulted in the Western Assemblage rocks being thrust eastward over the Eastern Assemblage rocks.

Erosion of the new highland brought about deposition of coarse detrital material to the east. At the easternmost extent of this deposition, the finer clastics interfinger with the normal marine sequence. Along the orogenic belt, the clastics overlie folded and faulted preorogenic rocks of both Western and Eastern Assemblages (Roberts, 1967). Overlap assemblage rocks are shown in Figure 2-7.

The Overlap Assemblage in the Eureka area consists of six formations that exhibit a composite thickness of approximately 13,000 feet (3,965 m) and that range in age from Mississippian to Permian (Roberts, 1967). These are, in ascending order, the Chainman Shale, Diamond Peak Formation, Ely Limestone, Brock Canyon Formation, and the correlative Carbon Ridge and Garden Valley Formations (Roberts, 1967). Major rock types include conglomerate, sandstone, shale, siltstone, claystone and limestone.

The Overlap Assemblage is represented by the Garden Valley Formation in the Sulphur Spring Range where it forms an abrupt north-south trending ridge east of Mt. Hope. It also occurs along the eastern side of Garden Valley. Four members of the formation have been recognized in this area (Roberts, 1967). They are, in ascending order, a limestone member (500 feet) (152.5 m), a conglomerate member (1,000 feet) (305 m), a highly resistant, ridge-forming, siliceous conglomerate member (1,000 feet) (305 m), and a purple and red shale and conglomerate member (550 feet) (167.8 m).

Only the basal limestone member of the Garden Valley formation is exposed in a small outcrop southeast of the mine site. The limestone has been highly altered to a skarn due to contact metamorphism by the Mt. Hope intrusive. The skarn is 400 to 500 feet thick, contains small brachiopod valves and is the host rock for the ore mined from the original Mt. Hope Mine. The beds overlie the Lower Vinini and are in fault contact with the Mt. Hope igneous complex to the west. The dip of these beds increases towards the contact with the igneous complex and locally they are tightly folded and cut by minor northeast-trending normal faults.

NEVADA BUREAU OF MINES BULLETIN 64

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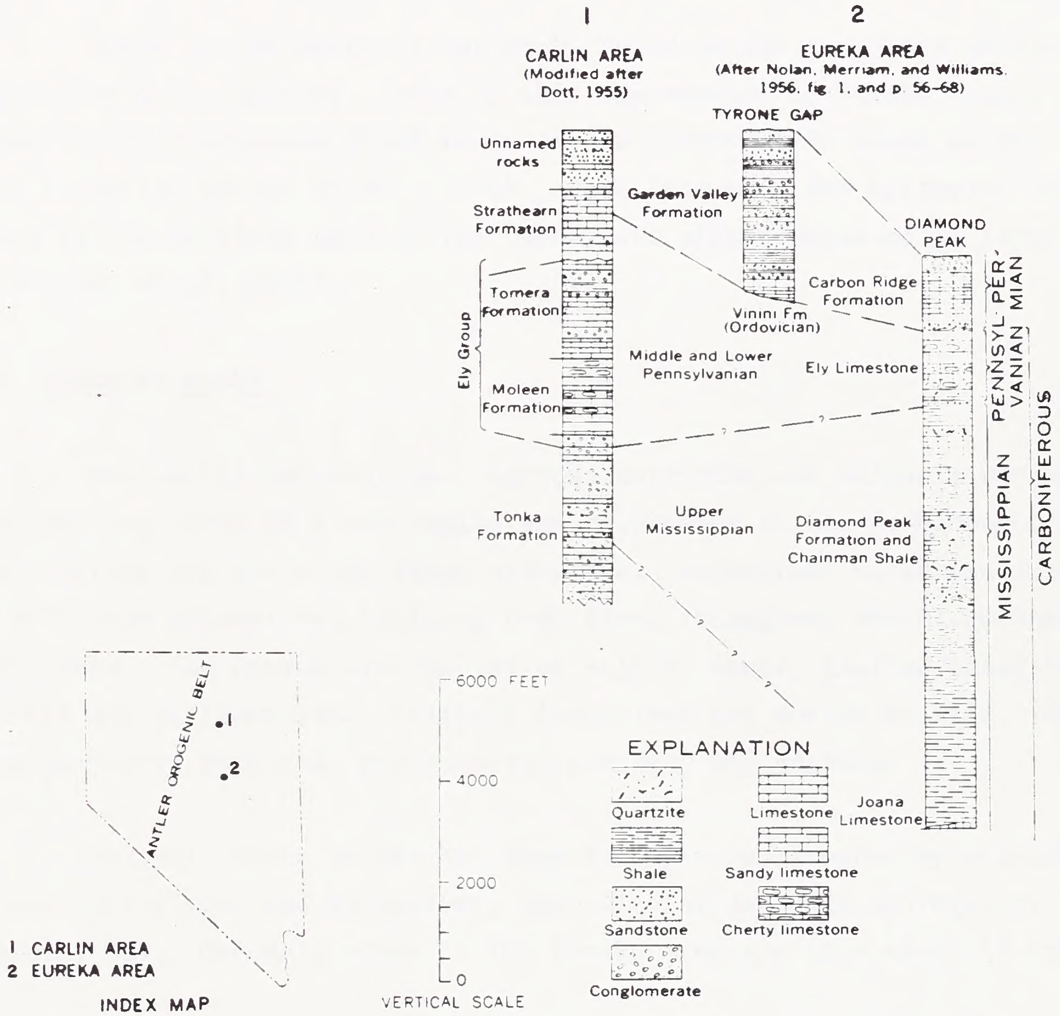

FIGURE 2-7
STRATIGRAPHIC COLUMNS OF THE OVERLAP ASSEMBLAGE ROCKS
CARLIN - EUREKA SEQUENCE

2.4.4 Mesozoic Rocks

Mesozoic rock units that were once present have largely been removed by erosion due to regional uplift brought about during the Laramide Orogeny. This Mesozoic compressional event also produced thrusting, intrusion of granitic batholiths, and severe deformation of the Paleozoic sedimentary sequence (Dott and Batten, 1976).

There are no Mesozoic age rocks found in the immediate vicinity of the Mt. Hope area, however, rocks of this age exposed in Eureka County are represented by Cretaceous fresh water strata (Figure 2-8) known as the Newark Canyon Formation (Nolan et al., 1956). Some intrusive and extrusive rocks exposed in the northern part of the County are also considered of late Mesozoic age (Roberts et al, 1967).

2.4.5 Cenozoic Rocks

During the Cenozoic age, igneous intrusion and volcanic activity led to the beginning of a new regime and culminated in the development of block faulting and Basin and Range structure. Widespread volcanism associated with this extensional faulting took place throughout the Oligocene, Miocene and Pliocene. The extrusives consist of silicic lavas, limited basaltic lavas, and tuffs and agglomerates. Tertiary intrusives are mostly silicic, primarily quartz porphyry, rhyolite, granodiorite porphyry and granite.

Cenozoic rocks in the Mt. Hope area are represented by silicic Tertiary intrusives, and extrusives, and alluvial deposits of Tertiary and Quaternary age. Cenozoic rocks in the Eureka area are also shown in Figure 2-8.

2.4.5.1 Tertiary Igneous Rocks (Ti)

Tertiary volcanic and intrusive rocks crop out extensively in the Roberts Mountains and surrounding areas. Extrusive rocks in the Roberts Mountains include rhyolitic tuffs and breccias, andesitic flows and thick flows of quartz latite (Merriam and Anderson, 1942). In Garden Valley, Table Mountain

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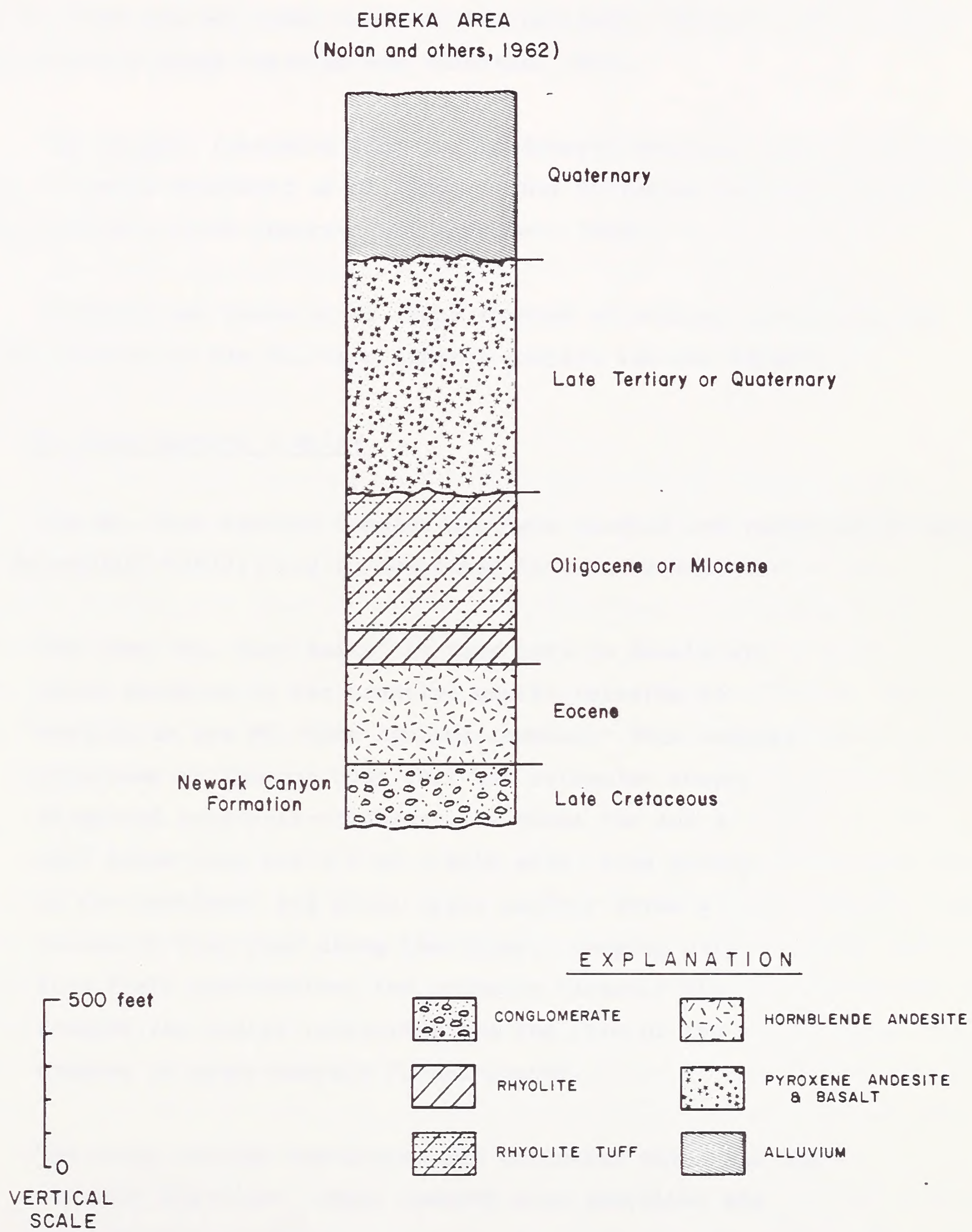


FIGURE 2-8

EUREKA AREA, NEVADA
GENERALIZED COMPOSITE STRATIGRAPHIC COLUMN
MESOZOIC AND CENOZOIC ROCKS

is composed of olivine basalt flows which were mapped as Tertiary Age (Merriam and Anderson, 1942).

Three major intrusive bodies occur in the Roberts Mountains area, and include Mt. Hope and two lower hills to the northwest (Roberts 1967), mapped as rhyolite porphyry plugs (Merriam and Anderson, 1942).

The largest intrusive body in the Roberts Mountain area is Whistler Mountain, 15 miles southeast of Mt. Hope. This intrusion has been mapped as a muscovite alaskite stock (Merriam and Anderson, 1942).

Tertiary age rocks at Mt. Hope consist of silicic intrusives and extrusives related to the Mt. Hope igneous complex and ore deposit.

2.4.5.2 Mt. Hope Igneous Complex

The Mt. Hope igneous complex has been studied and redefined in detail by A.A. Missallati (1973), and is described in part as follows:

> The term "Mt. Hope Suite" is used here to denote all rocks produced by the eruptive center referred to earlier as the Mt. Hope igneous complex. This complex comprises an igneous body that has irregular shape, elongated southeast-northwest, is about one and a half miles long and 3/4 of a mile wide, dips gently to the southwest and whose upper surface forms a series of flat tops along the slope. Judging only from field observation, the contacts commonly dip towards the center indicating the the form of the complex is approximately funnel-shaped.
>
> The rocks include intrusives and extrusive rhyolites and rhyolite breccias. Small country rock xenoliths are exposed in some places.

Missallati has also divided the suite into three distinct phases:

i- Intrusive phase(s) - Rhyolite porphyries,

ii- Extrusive phase(s) - Welded ash-flow tuff-and

iii- Explosive-brecciation phase(s) - Explosion-breccia (Intrusive breccia).

Each phase can be subdivided into a certain number of lithologically distinct rock units, based on its mode of origin, and the mineralogical, textural and structural variations produced during later igneous events. These variations are due to differing physical and chemical conditions in the hypabyssal environment and the physical and chemical effects of the extrusive.

The extrusives consist of a pumice flow or flows having undergone post-emplacement changes of devitrification and welding. The other extrusive constitutes the bulk of the pyroclastics in the Mt. Hope mine area and is termed an "ignimbrite". This extrusive is believed to have formed by deposition from incandescent, rapidly expanding magmatic gas clouds in which crystal droplets of exploding liquid and accidental fragments are suspended. (Missallati, 1973). These extrusives overlie the intrusive rhyolites. The rhyolites consist of two types; a veined rhyolite (quartz-feldspar) and a non-veined rhyolite.

The Permian limestone beds of the Garden Valley Formation have been intruded by numerous small rhyolitic dikes and by the Mt. Hope intrusive breccia. The breccia fragments consist of rhyolitic tuff, sediments and quartz porphyry in a rhyolitic matrix. This breccia is approximately 800 feet (244 m) wide and 4,000 feet (1,220 m) long, located along the southeast side of Mt. Hope, between the pyroclastic rocks and the altered limestone (skarn) of the Garden Valley Formation. These skarns host contact-silicate minerals and sulfide ore zones.

Other intrusives found at Mt. Hope (all of Tertiary age) are a poorly exposed dike-like granodiorite porphyry in the southeast area of Mt. Hope which may be part of a much larger igneous mass as depth; a quartz porphyry which

makes up the bulk of rock at depth in the area of the proposed mine pit, and a granite body at even greater depth.

2.4.5.3 Tertiary - Quaternary Alluvium

The surrounding valleys in the Mt. Hope area have not undergone any extensive studies in relation to valley fill. However, two major units of alluvium are recognized. The older alluvial fans or pediment surfaces were probably formed during the Late Tertiary (Pliocene) and Early Quaternary (Pleistocene) time following major uplift (Roberts, 1967). These fans consist of unconsolidated to poorly consolidated, poorly sorted gravel, sand and silt. The younger alluvium is of late Pleistocene and Recent age, and ranges from poorly sorted sands and gravels to fine-grained lacustrine sediments and playa deposits.

The younger alluvium of Kobeh and Garden-Pine Valleys is restricted to present day stream channels. Kobeh Valley contains approximately 5,000 feet (1,525 m) of fill at its western end which thins rapidly to the east. In southern Pine Valley the fill is about 5,000 feet (1,525 m) thick and rapidly reaches a thickness of approximately 10,000 feet (3,050 m) toward the central part of the valley. Diamond Valley is entirely covered by younger alluvium. The northern part of the valley is covered by a large playa deposit dominated by saline sills and clay (Roberts, 1967). The east-central portion of Diamond Valley (its deepest point) has fill of roughly 7,500 feet (2,287.5 m).

The alluvium of the Mt. Hope area lies directly east of the mine site and consists of semi-consolidated to unconsolidated material, poorly sorted and eroded from the Mt. Hope area. Much of the alluvium is slope wash, mainly of rhyolitic fragments and boulders. Farther down slope these grade to gravels and then grade to stream sediments. Because these deposits are found in the upper reaches of the regional drainage system, they are relatively thin and probably do not exceed several hundred feet in thickness.

2.5 Historical Geology

Historical geology, as in all historical studies, reveals the order in which events have succeeded one another. A general chronology serves as a framework in which historical data can be organized. The history of the earth has been organized into a chronological scheme known as the geologic time scale (see Fig. 2-9), which will help in understanding the sequence of events discussed further in this section.

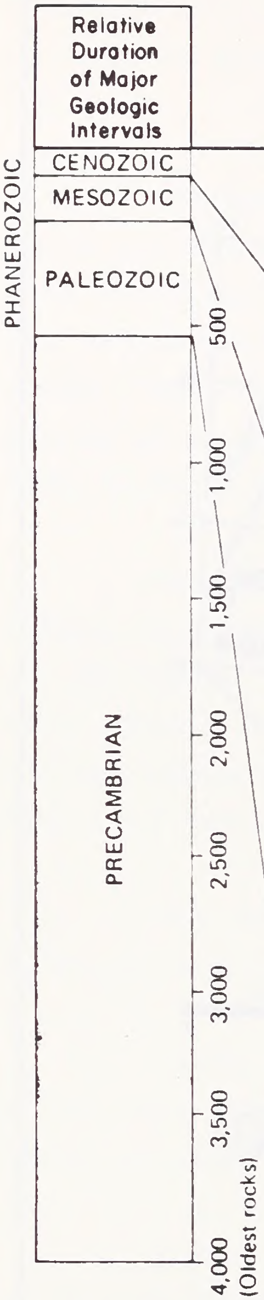
The Basin and Range province is underlain by a Precambrian igneous and metamorphic complex that is overlain by a thick sequence of Paleozoic rocks throughout most of the province. These Paleozoic sediments were deposited in the Cordilleran Geosyncline which began forming in the late Precambrian. Over 30,000 feet (9,146 m,) of sediments accumulated in this subsiding trough (Hunt, 1974).

The Lower Paleozoic sedimentary sequence consists of an Eastern carbonate assemblage (miogeosynclinal); a Western siliceous and volcanic assemblage (eugeosynclinal); and a transitional assemblage, separating the Eastern and Western assemblages (Figure 2-10).

Deposition of the three assemblages began in the Cambrian and persisted relatively undisturbed until the late Devonian when the Antler Orogeny interrupted. This orogeny lasted until middle Pennsylvanian time (Roberts, 1971), during which rock deformation by strong folding took place. The Western assemblage was then thrust over the Eastern assemblage carbonate sequence by a major, low-angle fault known as the Roberts Mountain thrust. The total movement of the upper thrust plate is approximately 90 miles (27 km) (Roberts, 1958).

After the Antler Orogeny, the remainder of the Paleozoic was characterized by deposition of clastic assemblages derived from the highlands created by the orogeny. These detrital sediments overlie both Eastern and Western assemblages and have been termed the "Overlap Assemblage" (Roberts, 1967).

The Mesozoic Era brought a spread of marine waters eastward across most of Nevada and into southern Idaho by Early Triassic time. The sea regressed



Era	Period		Epoch	Duration in Millions of Years (approx.)	Millions of Years Ago (approx.)
CENOZOIC	Neogene	QUATERNARY	Holocene		
			Pleistocene	3	3
		TERTIARY	Pliocene	4.0	7
			Miocene	19	26
	Paleogene		Oligocene	12	38
			Eocene	16	54
			Paleocene	11	65
MESOZOIC	Cretaceous			71	136
	Jurassic			54	190
	Triassic			35	225
PALEOZOIC	Permian			55	280
	Carboniferous		Pennsylvanian	65	325
			Mississippian		345
	Devonian			50	395
	Silurian			35	430
	Ordovician			70	500
	Cambrian			70	570

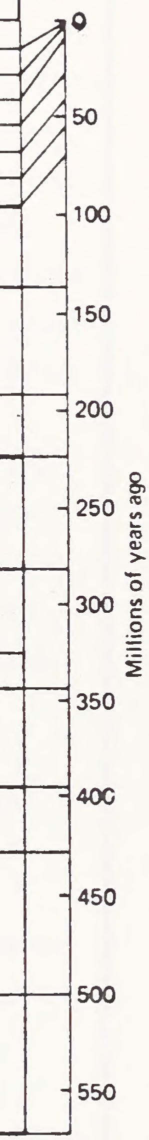
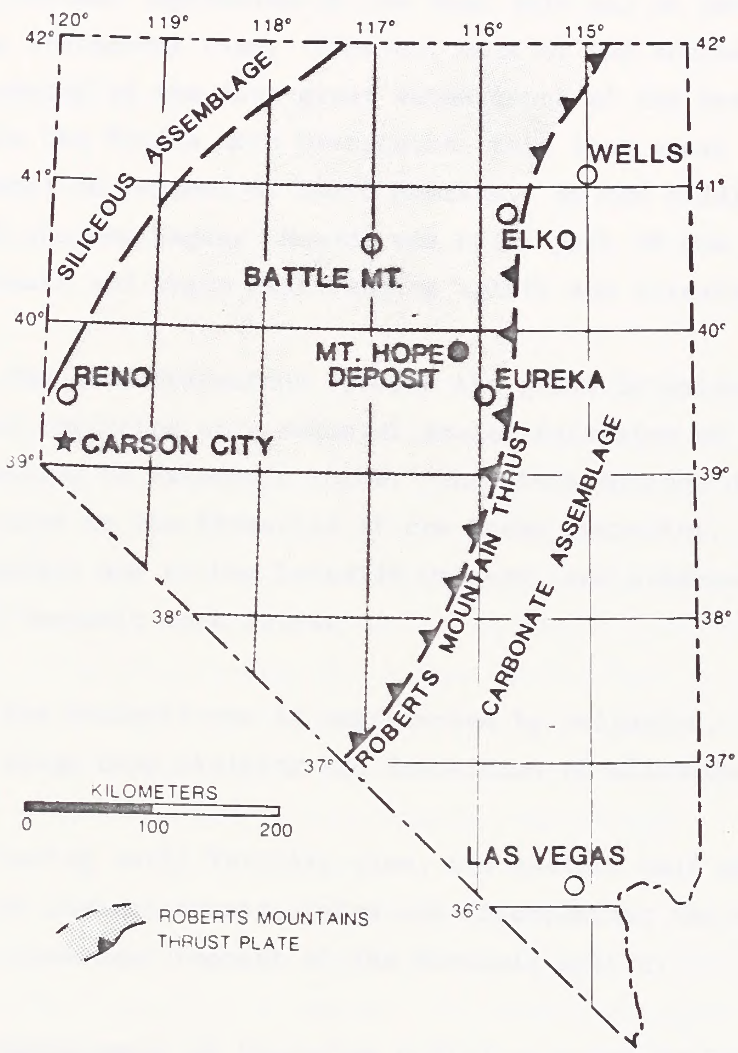


FIGURE 2-9
GEOLOGIC TIME SCALE

Source: Modified from McAlester and Hay, 1975.



Source EXXON MINERALS COMPANY

MT. HOPE MOLYBDENUM PROJECT

LOWER PALEOZOIC SEDIMENTARY SEQUENCE OF NEVADA

U.S. Department of the Interior
Bureau of Land Management

FIGURE 2-10

by the Late Triassic, leaving all of eastern Nevada above submergence. This condition persisted for eastern Nevada through Late Jurassic time. Eastern Nevada was now part of a long narrow landmass known as the Mesocordilleran geanticline, bordered by the Columbian Sea to the west and the Sundance Sea to the east.

Further regression of the seas left all of Nevada above sea level by Early Late Cretaceous time. However, much of the southern United States was being inundated by the last great submergence of the North American continent. Just before the Middle Late Cretaceous, this last great transgression submerged almost 50 percent of North America. By the Middle Late Cretaceous the retreat of the sea began. Nevada was still part of the Mesocordilleran geanticline landmass and began experiencing uplift and volcanism during the Cretaceous.

The Late Cretaceous brought the great Laramide Orogeny, involving folding and thrusting on a colossal scale, intrusion of granitic batholiths, and deformation to Paleozoic rocks. The final outcome of this compressional event resulted in the formation of the Rocky Mountains. Nevada experienced regional uplift due to the Laramide Orogeny, and subsequent erosion removed nearly all Mesozoic rock units.

The Cenozoic era is represented by volcanics, igneous intrusives, Basin and Range type faulting and deposition of alluvium.

During early Tertiary time, the eastern half of the Great Basin was covered with lowland swamps, lakes and floodplains; the western half was a low upland, an erosional remnant of the Mesozoic uplift.

Emplacement of intrusive bodies occurred during Tertiary time, mainly during late Eocene and early Oligocene epochs, and continued to the Pliocene epoch.

Basin and Range type faulting also commenced during middle Tertiary time; linear mountain ranges and intervening intermontane basins, which collected sediments eroded from the ranges, began to form at this time. This

faulting continued to increase and was most intense during Pliocene and Pleistocene time.

The Tertiary is well represented in the Mt. Hope area by multiple intrusive episodes which formed the Mt. Hope igneous complex and ore deposit (Westra, 1980). The Mt. Hope igneous complex evidently was formed about 36 million year ago, during Oligocene time (Silberman and McKee, 1971).

2.6 Mt. Hope Geology

Mt. Hope lies at the southeastern end of the Battle Mountain - Eureka mineral belt and within the Antler orogenic belt of the Cordilleran geosyncline.

Early Paleozoic eugeosynclinal sediments of the Western Assemblage are represented at Mt. Hope by the Ordovician Vinini Formation. The Lower Vinini consists of a basal unit of silty argillite, shale and chert, a middle unit of shale with calcareous sandstone lenses, and a unit of lava flows and tuff near the top. The Upper Vinini is primarily bedded cherts and organic shales and is of limited occurrence at Mt. Hope. The Vinini has been contact metamorphosed near intrusive porphyries and is locally a host for molybdenum mineralization. The Vinini Formation forms the basal unit of the Roberts Mountains thrust plate and has been emplaced above the early to mid-Paleozoic miogeosynclinal sediments of the Eastern Assemblage.

The only exposed representative of the Eastern Assemblage at Mt. Hope is the Devonian Devil's Gate Limestone, composed of blue and dark gray limestone with small calcite veinlets. The limestone occurs as isolated pods within the lower Vinini and has been interpreted by Walker (1962) as tectonic slices bounded by thrust faults caught up in the lower part of the Roberts Mountain thrust. It, therefore, has no roots and is not an actual outcrop at Mt. Hope.

Sediments deposited subsequent to the Antler Orogeny are mostly carbonates and clastic rocks of the Overlap Assemblage. This assemblage is represented at Mt. Hope by the basal limestone member of the Permian Garden Valley Formation. These beds uncomformably overlie the thrust deformed Lower Vinini and are in

fault contact with the Mt. Hope igneous complex. The limestone has been highly altered to a marble or calc-silicate skarn due to contact metamorphism by intrusive episodes. The skarn is 400 to 500 ft (122 to 152 m) thick, contains small brachiopod valves and hosts zinc ore. Retrograde alteration is common. The dip of these beds increases toward the contact with the igneous complex, and locally, they are tightly folded and cut by minor northeast-trending normal faults.

2.6.1 Mt. Hope Igneous Complex

Multiple intrusive episodes at Mt. Hope are responsible for the Mt. Hope igneous complex or suite, which was emplaced during a regional pulse of volcanism dated from 40 million to 20 million years ago (mid-Tertiary). The igneous body has an irregular shape, is elongated in a southeast-northwest direction, is approximately 2.1 km (1.3 miles) long and 1.4 km (0.87 miles) wide and dips gently to the southwest. Field observations from contacts suggest that the body is roughly funnel shaped. The complex consists of intrusive and extrusive porphyritic volcanics. According to Missallati (1973) the rocks are slightly peraluminous high silica rhyolites (SiO_2 = 75%), enriched in alkalis and lithophile elements. Age of the Mt. Hope complex ranges from 32 to 38 million years (Westra and Riedel, 1981).

The formation of the Mt. Hope complex has been summarized by Missallati (1973) as follows:

1) Hypabyssal emplacement of the magma and the formation of Mt. Hope intrusive arch, followed by early violent eruption of pumice flows.

2) Caldera formation, or subsidence, followed by less violent eruption of fluidized magma to form a nuee ardente of the Katmai type.

3) Migration of the magma to low pressure zones of fractured rocks and the formation of explosion-breccia.

4) End stage - the formation of the intrusive breccia. This stage either was accompanied or followed by ore emplacement in the district.

The events of the Mt. Hope complex allow three distinct phases to be recognized, each one possessing lithologically different rock units due to diverse physical and chemical conditions. The phases are an intrusive phase(s) of rhyolite porphyries, an extrusive phase(s) of welded ash flow tuff and a explosive-brecciation phase(s) of intrusive nature.

The extrusives consist of multiple pumice flows with a minimum thickness of 1,475 ft (450 m) and having undergone post-emplacement changes of devitrification and welding. The ash flow tuffs were deposited highest in the Mt. Hope complex and fill two or more small cauldrons. Millallati (1973) has defined another extrusive to be present at Mt. Hope and has termed it as an "ignimbrite", formed by deposition of crystal droplets and fragments suspended in a rapidly expanding, incandescent magmatic gas cloud. Both extrusives overlie the intrusive rhyolites and are separated from each other in the cauldrons by arcuate intrusive breccias. These explosion breccias formed during the evacuation of shallow magma chambers by the migration of material into low pressure zones and ring fractures formed by the magma movement. The breccia is approximately 800 ft (244 m) wide and 4,000 ft (1,220 m) long, and is located along the southeast side of Mt. Hope. The breccia fragments consist of rhyolitic tuff, sediments and quartz porphyry in a rhyolitic matrix. These breccias separate the pyroclastics from the sedimentary country rock.

The Permian limestone beds of the Garden Valley Formation have been intruded by numerous rhyolitic dikes and altered to a skarn due to contact with the Mt. Hope intrusives. These beds were then invaded by hydrothermal fluids of presumed magmatic origin which added components and, once introduced to the country rock, reacted to form contact - silicate minerals and simultaneously deposited sulfides to form sulfide ore zones. The hydrothermal fluids readily invaded the limestone beds because of major structural features of the Mt. Hope mine area. These features, low angle and high angle faults and fissure zones, are probably associated with the Mt. Hope intrusive

episodes. The combined structural features acted as channelways for the hydrothermal fluids to ascend into the limestone beds.

There are three major porphyry units, distinguished by differing phenocryst and matrix textures, which intruded coeval rhyolitic tuffs. The units are defined as "typical", "aplitic" and "coarse" quartz porphyries containing K-feldspar, quartz and plagioclase phenocrysts in a matrix of fine-grained quartz and K-feldspar. Typical quartz porphyry contains 0.5 to 5 mm phenocrysts in a cryptocrystalline groundmass. Aplitic quartz porphyry contains 0.5 to 5 mm phenocrysts in an aplitic groundmass. Coarse quartz porphyry contains 2 to 8 mm phenocrysts in an aplitic groundmass. (Schwarz, 1983).

Two distinct loci are known to exist in which deeper coaxial stocks of aplitic and coarse porphyries intrude an irregular mass of typical quartz porphyry. This irregular mass is situated along the southern boundary of the complex and the two deeper intrusions delineate an "eastern" and "western" system.

Schwarz (1983) describes these systems as follows:

"In the eastern and western systems two side-by-side 1,312 ft (400 m) diameter aplitic quartz porphyry stocks intrude typical quartz porphyry at centers 2,300 ft (700 m) apart. The stocks are elongated along N 70° W trending axes. The western stock rises to 6,890 ft (2,100 m) elevation (656 ft [200 m] below surface); the eastern stock, to 6,070 ft (1,850 m) (984 ft [300 m] below surface). These stocks merge at depth and localize asymmetric haloes of alteration and molybdenum mineralization mostly in typical quartz porphyry, the major host for molybdenum mineralization.

Coarse quartz porphyries coaxially intrude aplitic quartz porphyry. Coarse porphyries, rising to 5,577 ft (1,700 m) and 5,675 ft (1,730 m) elevations beneath the western and eastern aplitic stocks respectively, localize weakly-developed molybdenum shells. Other intrusive bodies are believed to be late-stage dikes of fine grained granite and dacite porphyry."

These intrusive episodes caused extensive fracturing, shearing and faulting of the igneous rocks and country rock. High angle normal faults intersect in the south-central part of the Mt. Hope complex. Large scale landslides possibly related to caldera subsidence may have occurred along several arc-shaped normal faults. The most prominent of these are the Ravine Fault and the Mt. Hope Fault. The Mt. Hope Fault has a north strike, dips 40° to 50° east and is marked by a gouge and fractured rock zone from 100 ft (10-30 m) thick.

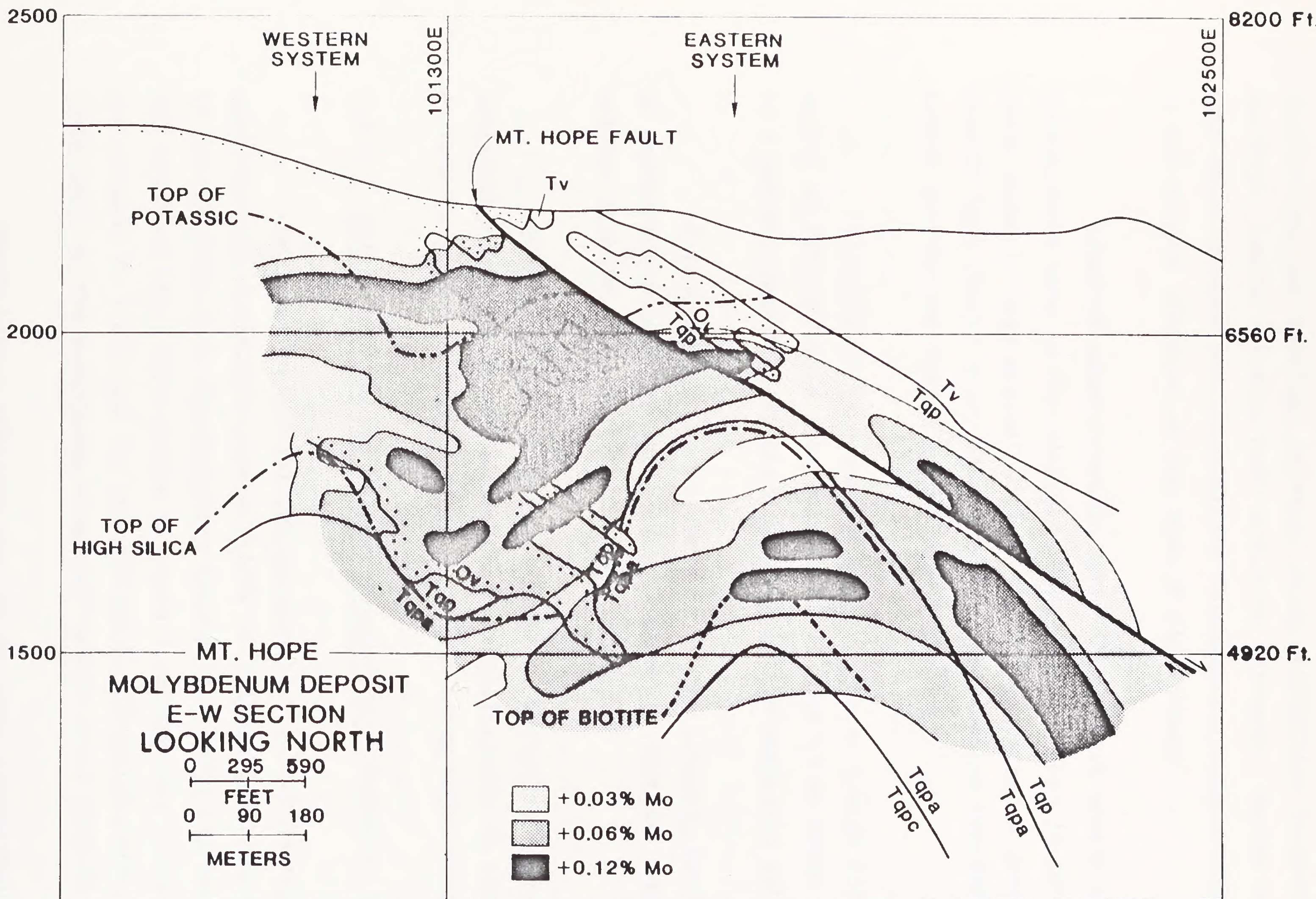
2.6.1.1 <u>Alteration</u> (Schwarz, 1983)

Patterns of alteration are developed symmetrically around and within igneous rocks of the Mt. Hope complex and adjacent sediments. Alteration zones are defined by mineral assemblages, chemical composition, and/or characteristics of veins and selvages. The peripheral argillic zone grades inward and at depth to the potassic zone. The periphery of the potassic zone contains a superimposed phyllic subzone, and the deep potassic zone contains discrete high silica and biotite subzones. Best molybdenum mineralization occurs within the potassic zone and decreases with depth, often within a high silica subzone (see Figure 2-11).

Argillic alteration in igneous rocks is characterized by complete replacement of plagioclase, and local replacement of K-feldspar, by clay, chlorite and carbonates, and in the Vinini by a weak hornfelsic fabric of clay, sericite, chlorite, epidote and carbonates -- with traces of galena and sphalerite, and with one percent pyrite in hairline veinlets. Volumes of alteration minerals and sulfide-quartz veinlets increase inward and downward. Up to 10% pyrite may be present locally in the innermost argillic zone -- where 0.1 m diameter concretionary masses, "orbicles", of carbonate and clay occur around sulfide nuclei.

In the potassic zone in intrusive rocks, commonly fine-grained hydrothermal orthoclase replaces original feldspars, and quartz is recrystallized. Pyrite averages less than one percent.

The phyllic subzone discontinuously overprints the periphery of the potassic zone. In igneous rocks, sericite replaces K-feldspar and remnant



KEY

Ov = Ordovician Vinini Formation
Tv = Tertiary volcanics
Tqp = Tertiary quartz porphyry
Tqpa = Tertiary quartz porphyry, aplitic
Tqpc = Tertiary quartz porphyry, coarse

Source: EXXON MINERALS COMPANY

MT. HOPE MOLYBDENUM PROJECT	
MT. HOPE MOLYBDENUM DEPOSIT AND ALTERATION ZONES	
U.S. Department of the Interior Bureau of Land Management	FIGURE 2-11

plagioclase, and develops selvages along molybdenite veinlets. In Vinini hornfels, quartz veinlets have sericitic selvages. Pyrite content is less than three percent and chalcopyrite veinlets are common. Fluorite increases to 0.5 percent fluorine at the base of the subzone.

Areas of sharp increase both in stockwork quartz veins and flood silica occur deep in the potassic zone. Greater than 30 percent volume quartz veins marks a "high silica" zone -- which may contain 2 percent pyrite. Coaxial high silica zones of the western and eastern systems are symmetrical around aplitic and coarse quartz porphyry stocks.

Transitions from potassic alteration to a high silica subzone are marked by discontinuous intervals up to 16 feet (5 m) thick characterized by up to 5 percent magnetite in patches and chlorite-magnetite veinlets.

A biotite subzone at the base of the potassic zone is characterized by decreasing K-feldspar replacement, secondary biotite, increasingly more primary biotite, and by relict plagioclase.

Throughout the mineralized system, a phyllic overprint affects plagioclase and mafic sites. Supergene argillization is present from the surface to a 65 foot (20 m) depth -- deeper along major fractures.

2.6.1.2 <u>Metal Zonation and Veinlet Paragenesis</u> (Schwarz, 1983)

Drill holes and surface geochemistry reveal haloes of metal zonation approximately concentric around stocks of aplitic quartz porphyry. The sequence of metalization from the periphery inward is: Pb-Zn (Ag-Mn-Sn), Cu-F (Zn-Ag-Pb) and Mo-W (F). Halo assays approach 1 percent Zn, 2,000 ppm Pb, 0.5 oz/T Ag, 1.3 percent F, 2,000 ppm Cu, and 900 ppm W. Tungsten, most anomalous in the lower half of the molybdenum zone, and metals other than Mo are subeconomic.

Early barren veinlets are cut by later quartz-poor, Mo-rich veinlets which are in turn cut by quartz-rich, Mo-poor veinlets. Pyrite and base metal sulfide veinlets cut all earlier veinlets.

2.6.1.3 Molybdenum Mineralization (Schwarz, 1983)

Molybdenum mineralization -- categorized by molybdenite (MoS_2) habit in veinlets -- occurs as "typical", "gaudy", "blue quartz", and "paint".

"Typical" zones, comprising 75 percent of mineralization, contain 0.5 to 5 mm thick veinlets which consist of quartz $\pm$ fluorite $\pm$ orthoclase enclosing 0.25 to 1 mm grains and grain aggregates of molybdenite.

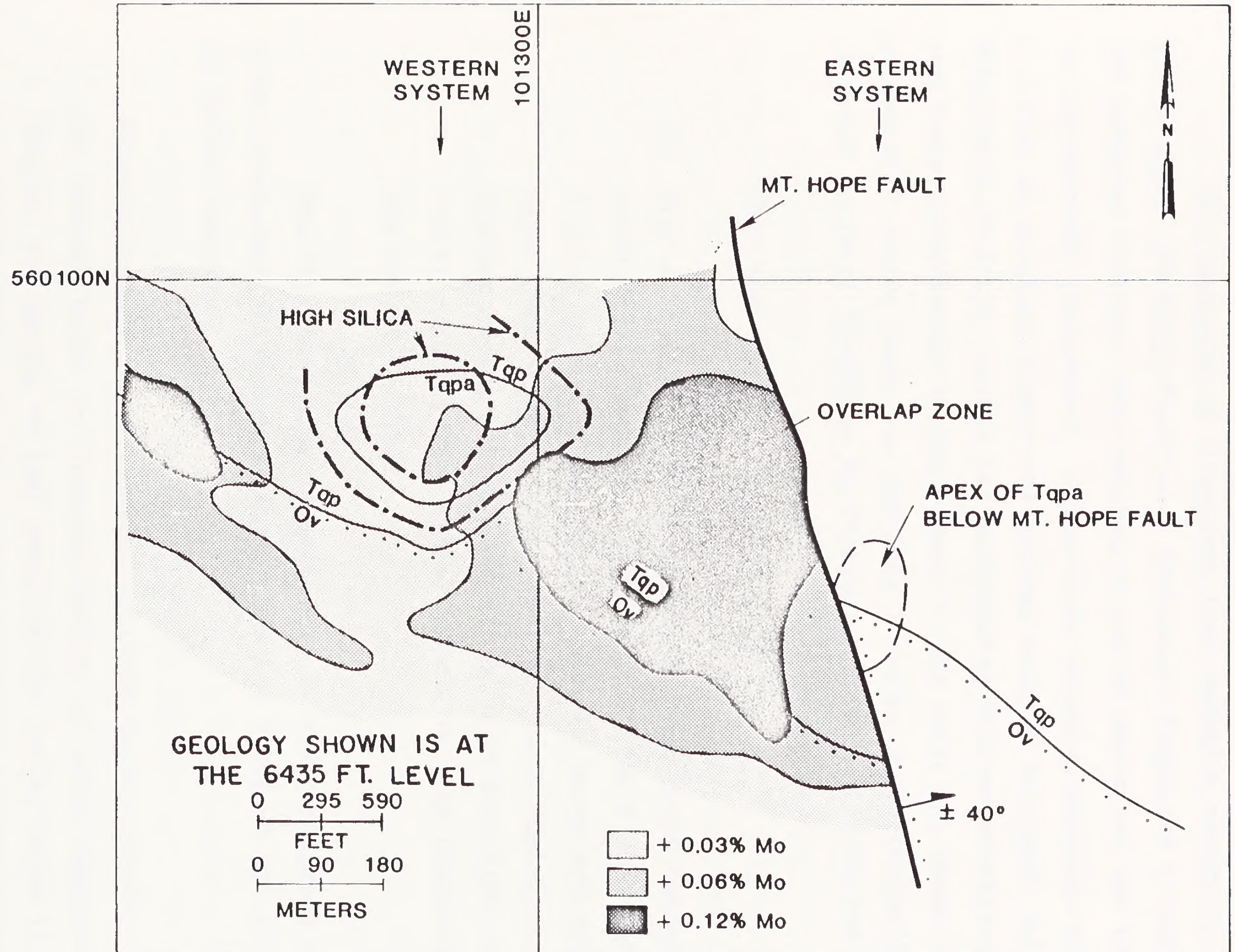
"Gaudy" zones, comprising approximately 10% of mineralization, contain 5 to 20 mm thick veinlets of quartz $\pm$ fluorite $\pm$ carbonate minerals enclosing 5 to 20 mm aggregates of molybdenite grains.

"Blue quartz" zones, comprising 10 percent of mineralization, occur near the top of high silica subzones. Blue quartz consists of veinlets, streaks, and patches, 3 to 10 mm thick, of granular quartz containing 0.2 mm smears, and sparsely distributed 0.05 mm grains, of molybdenite.

Molybdenite "paint" comprising 5 percent of mineralization, occurs in smeared and slickensided veinlets less than 2 mm thick containing submicron to 0.2 mm grains of molybdenite.

At the margins of mineralization, Mo abruptly increases from less than 25 ppm to more than 200 ppm within 20 m. Extensive zones containing in excess of 0.06 percent Mo are common within mineralized areas. Mo gradually decreases with depth within high silica subzones.

Major molybdenum mineralization occurs as coaxially stacked, "shells" within the potassic alteration zone and around the aplitic quartz porphyry stocks of the eastern and western systems. Shells of mineralization overlap and interpenetrate in the area between the eastern and western systems (the "overlap" zone). Molybdenum contributed by the eastern and western systems to the overlap zone appears to be additive, thus providing the large body of good grade molybdenum mineralization currently under investigation (Figure 2-12).



KEY

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Tv = Tertiary volcanics
Tqp = Tertiary quartz porphyry
Tqpa = Tertiary quartz porphyry, aplitic
Tqpc = Tertiary quartz porphyry, coarse

Source: EXXON MINERALS COMPANY

MT. HOPE MOLYBDENUM PROJECT

MOLYBDENUM MINERALIZATION SHOWING EASTERN AND WESTERN SYSTEMS AND OVERLAP ZONE

U.S. Department of the Interior
Bureau of Land Management

FIGURE 2-12

2.7 Tectonics and Seismicity

2.7.1 Regional Tectonics and Seismicity

The beginning of Oligocene time marked a change in the tectonic regime of the Basin and Range Province. Previously dominated by compression due to the Laramide Orogeny, this shifted to one of extension and is responsible for the present-day topography. North-south trending mountain ranges formed due to a series of parallel horsts and grabens bounded by normal antithetic faults. This block faulting reached its peak during Pliocene-Pleistocene time and continues episodically to the present. The Basin and Range is tectonically and seismically active today and exhibits features characteristic of high-level tectonic activity according to Thompson and Burke (1974) and Keller (1975).

They are:

1) High heat flow (2HFU or more); 2) thin crust (about 30 km vs. 40-50 km in the Rocky Mountains); 3) low P wave velocities of 7.7-7.9 km/sec in the upper mantle (P waves are primary seismic waves that cause compressional motion in the earth and are the fastest moving seismic waves); 4) high elevation; 5) high electrical conductivity; and 6) extensive late Cenozoic volcanism and normal faulting.

The high heat flow is evidenced by the widespread hot springs and other geothermal phenomena. Hot springs are found at the following locations in Eureka County:

Beowawe Geysers	-- Beowawe, northern Eureka County.
Hot Springs Point	-- Crescent Valley, 10 miles southeast of Beowawe.
Shipley Hot Spring	-- just south of the Sadler Ranch in Diamond Valley.
Hot Spring Hill	-- five miles southwest of Lone Mountain, north of Bartine Ranch.
Walti Hot Springs	-- 17 miles south of Cortez, western foothills of Simpson Park Range.

Klobe Hot Springs -- on the Kitchen Meadows Road (west of Town of Eureka toward Ardans and Antelope Valley).

In addition to the exceptionally thin continental crust under the Basin and Range area, the mantel appears abnormally inelastic (Gilluly, Waters and Woodford, 1967). Other signs of recent structural deformations are evidenced by the number of Holocene fault scarps; warping and faulting of Pleistocene and Holocene shorelines; measurable horizontal and vertical displacement of benchmarks and reference markers in addition to measurement by tiltmeters (Hunt, 1974) and; numerous valleys in which alluvial deposits show displacement (Hunt, 1974).

Atwater (1970) characterized the Great Basin as a wide, soft zone that is accomodating oblique divergence between the Pacific and North American plates. This divergence is manifested by crustal extension with a strong right-lateral component that has produced approximately 80 to 120 miles (128 to 192 km) of displacement across the western Great Basin (Stewart et al, 1968).

One theory suggests that the Basin and Range area overlies a subcontinental zone of sea floor spreading (Gilluly, Waters and Woodford, 1967).

Fault studies suggest that Quaternary seismicity in the Great Basin was sporadic and that the foci of activity shifted with time (Slemmons, 1967). Wallace (1977) indicated that, for any given period of time, faults in some ranges were repeatedly active, while faults in nearby ranges were not. Even along a given fault or complex of faults, certain segments appear to have been repeatedly active, while adjacent segments had little or no activity. The recurrence interval of major earthquakes for any given location in Nevada appears to be on the order of several thousand years (Ryall, 1977).

It should be noted that earthquakes do not always occur along faults. In many cases, large earthquakes have created new fracture zones (Ryall, 1977). The 1932 Cedar Mountain earthquake of western Nevada (see Table 7-1) created a zone of surface rupture extending some 37 miles (60 km) long and 4 to 9 miles (6.5 to 14.5 km) wide (Ryall, 1977).

Nevada is bounded on the east and west by seismically active zones where most of the crustal movement is concentrated. The eastern boundary, known as the Intermountain Seismic Belt, is a 1300-km-long, 100-km-wide belt extending from Arizona northward thru west-central Utah and into Montana. This belt is the third most seismically active zone in the United States.

The western boundary, known as the Ventura-Winnemucca Seismic Zone, is a 600-km-long belt extending from Ventura, California north-northeastward to Winnemucca, Nevada. This belt is the most active seismic belt in the United States. Nevada's seismic activity has been concentrated in the Ventura-Winnemucca Zone and between 1934 and 1960, Nevada was the most seismically active area in the western conterminous United States (Slemmons, 1965; Wallace, 1977).

The Mt. Hope site is approximately 125 miles (200 km) east of the Ventura-Winnemucca Seismic Zone.

A summary of major seismic events within the state of Nevada is presented in Table 2-2 and Figure 2-13 shows earthquake epicenters within a 155 mile (250 km) radius of the proposed site.

2.7.2 Major Earthquakes within Nevada

Nevada has been the locus of five great earthquakes (magnitude greater than 7) since 1840. Descriptions of each (with the exception of the Stillwater earthquake) are provided from the NOAA (1973).

Stillwater, Nevada Earthquake (1845-1852).

The Stillwater earthquake, centered somewhere between Pyramid Lake and the Stillwater area is known only from Indian accounts. The earthquake is reported to have knocked people down, caused landslides and produced brief changes in river flows.

Owens Valley Earthquake of March 26, 1872.

Time of occurrence.--About 02:30.

Table 2-2 Summary of Recent Earthquakes in Nevada 1845 - 1980 (Intensity V and Greater)

Year	Date	Locality	Epicenter Lat. (N) (Degrees)	Epicenter Long. (W) (Degrees)	Affected Area (Sq.Mi)	Intensity (Mercalli)	Magnitude (Richter)
1845-1852 period		Stillwater-Pyramid Lake, Nev.	-	-	-	X	-
1872	March 23	Northeast of Austin, Nev.	40	117.5	12,000	VI	
1887	June 3	Carson City, Nev.	39	120	-	VII	
1896	Jan. 27	Carson City, Nev.	39	120	-	VI	
1901	July 26	Nevada	40.8	115.7	3,500	VII	5.6
1908	Aug. 18	Eureka, Nev.	41	124	6,000	VII	5.6
1914	Feb. 18	Near Reno, Nev.	39.5	120	-	VI	5.0
1914	Apr. 24	Near Reno, Nev.	39.5	120	100,000	VII	5.6
1915	Oct. 2	Pleasant Valley, Nev.	40.3	117.6	500,000	X	7.75
1915	Oct. 5	Near Nev. - Utah border	40.1	114	-	V	4.2
1915	Nov. 17	Elko, Nev.	40.9	115.8	-	V	4.2
1916	Feb. 2	Western Nevada	40.5	119.5	100,000	VI	5.0
1916	Aug. 3	Nevada	41.0	117.5	-	IV-V	4.2
1919	Sept. 15	Eureka, Nev.	41	124	-	VII	5.6
1930	Apr. 9	Lake Tahoe	39	120	19,000	VI	5.0
1930	Apr. 12	Fernley, Nev.	39.5	119	15,000	VI	5.0
1932	Dec. 20	Cedar Mountain area	38.7	117.8	500,000	X	7.3
1933	June 25	Wabuska, Nev.	39.1	119.3	70,000	VII	5.6
1934	Jan. 30	Southeast of Hawthorne, Nev.	38.3	118.4	110,000	VIII-IX	6.8
1936	Sept. 19	Hoover Dam, Nev.	36	115	-	V	4.2
1937	Apr. 24	West-central Nev.	39	117	20,000	V	4.2
1937	Apr. 27	Hoover Dam, Nev.	36	115	-	V	4.2

Table 2-2 Summary of Recent Earthquakes in Nevada 1845 - 1980 (Intensity V and Greater) (Cont)

Year	Date	Locality	Epicenter Lat. (N) (Degrees)	Epicenter Long. (W) (Degrees)	Affected Area (Sq.Mi)	Intensity (Mercalli)	Magnitude (Richter)
1937	June 18	Hoover Dam, Nev.	36	115	-	V	4.2
1937	Nov. 11	Hoover Dam, Nev.	36	115	-	V-VI	4.6
1939	Jan. 11	Southeast of Minden, Nev.	38.8	119.6	8,000	VI	5.0
1939	May 4	Near Las Vegas, Nev.	37.0	114.8	7,000	VI	5.0
1939	May 11	Northeast of Mina, Nev.	38.5	117.8	38,000	VI	5.0
1942	June 4	Boulder City, Nev.	36.0	114.9	-	V	4.2
1942	Sept. 8	Boulder City, Nev.	36.0	114.9	-	V	4.2
1942	Dec. 3	West of Wadsworth, Nev.	39.9	119.0	24,000	VI	5.0
1943	Aug. 8	Excelsior Mtns., Nev.	38.2	118.2	34,000	VI	5.0
1948	Nov. 2	Hoover Dam, Nevada	35.9	114.8	-	VI	5.0
1948	Dec. 29	Near Verdi, Nev.	39.5	120.1	40,000	VII	5.6
1952	Feb. 8	Boulder City, Nev.	36.0	114.9	-	V	4.2
1952	Feb. 20	Boulder City, Nev.	36.0	114.9	-	VI	5.0
1952	May 9	North of Carson City, Nev.	39.4	119.7	3,000	VI	5.0
1953	Sept. 25	Near Reno, Nev.	39.6	119.8	12,000	VI	5.0
1954	July 6	East of Fallon, Nev.	39.4	118.5	130,000	IX	7.0
1954	July 6	Southeast of Fallon, Nev.	39.3	118.5	-	VIII	6.5
1954	Aug. 23	East of Fallon, Nev.	39.6	118.5	150,000	IX	7.0
1954	Aug. 31	Dixie Valley, Nev.	39.6	118.2	-	VII	5.6
1954	Dec. 16	Dixie Valley, Nev.	39.3	118.2	200,000	X	7.1
1955	Jan. 10	Southeast of Lovelock, Nev.	39.9	118.4	-	VI	5.0

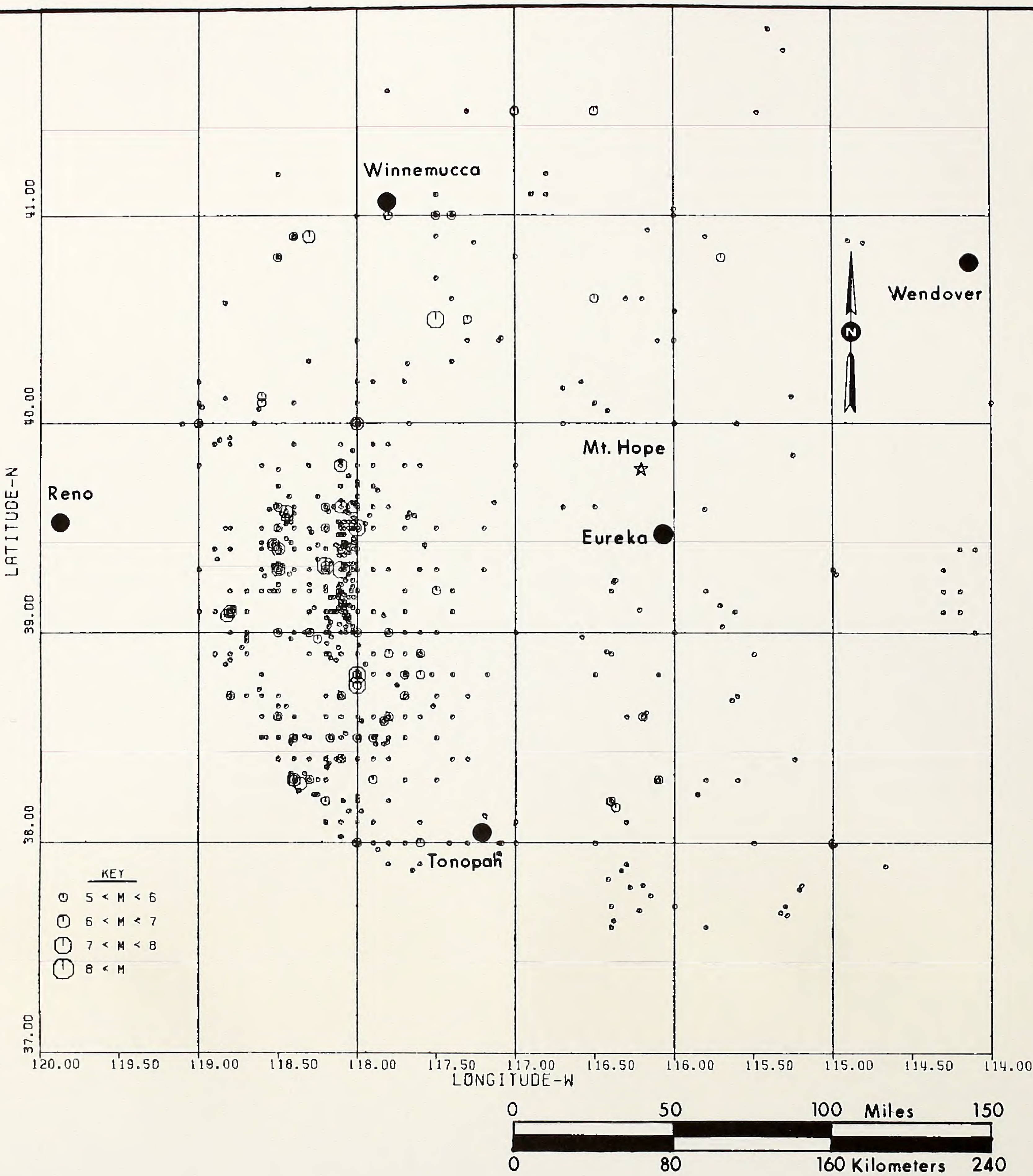
Table 2-2 Summary of Recent Earthquakes in Nevada 1845 - 1980 (Intensity V and Greater) (Cont)

Year	Date	Locality	Epicenter Lat. (N) (Degrees)	Epicenter Long. (W) (Degrees)	Affected Area (Sq.Mi)	Intensity (Mercalli)	Magnitude (Richter)
1955	Jan. 10	Southeastern Nevada	37.0	114.5	-	V	4.2
1955	Aug. 8	Near Hawthorne, Nev.	38.5	118.8	9,000	V	4.2
1956	Dec. 31	Near Hawthorne, Nev.	38.3	119.0	6,000	VI	5.0
1958	April 19	Near Boulder City, Nev.	36.0	114.9	-	VI	5.0
1959	March 22	Dixie Valley, Nev.	39.6	118.0	50,000	VI	5.0
1959	June 23	North of Schurz, Nev.	39.1	118.8	35,000	VI	5.0
1961	July 3	West of Winnemucca, Nev.	40.9	118.4	10,000	V	4.2
1962	July 20	Near Dixie Valley, Nev.	39.8	118.1	13,500	V	4.2
1963	Mar. 25	Near Boulder City, Nev.	44.8	110.3	Local	V	4.3
1963	April 23	Hoover Dam, Nev.	36.0	115.0	Local	V	4.2
1964	Feb. 20	Eastern Nev.	39.4	114.2	-	V	4.2
1964	Mar. 22	North of Hawthorne, Nev.	38.8	118.7	7,500	V	4.2
1964	Sept. 23	Near Boulder City, Nev.	35.9	114.8	3,000	V	4.2
1964	Oct. 30	Dyer, Nevada	37.7	118.0	-	VI	5.0
1966	Apr. 2	South of Luning, Nev.	38.4	118.1	-	VI	5.0
1966	Aug. 16	Southern Nevada	37.4	114.2	20,000	VI	5.0
1966	Sept. 22	Southern Nevada	37.4	114.2	-	V	4.2
1968	Feb. 5	Mt. Montgomery, Nev. area	38.0	118.4	8,000	VI	5.0
1968	Jan. 30	North-central Nevada	41.0	117.4	3,500	V	4.2
1968	Feb. 21	Central Nevada	38.6	116.3	-	V	4.2
1968	July 6	North-central Nevada	41.0	117.4	9,500	V	4.2

Table 2-2 Summary of Recent Earthquakes in Nevada 1845 - 1980 (Intensity V and Greater) (Cont)

Year	Date	Locality	Epicenter Lat. (N) (Degrees)	Epicenter Long. (W) (Degrees)	Affected Area (Sq.Mi)	Intensity (Mercalli)	Magnitude (Richter)
1971	Dec. 8	Southern Nevada near Caliente	37.7	115.0	13,000	V	4.8
1973	Feb. 9	Southern Nevada near Beatty	36.8	115.9	Local	V	4.2
1976	June 10	Central Nevada near Eureka	39.6	115.9	Local	V	4.2
1977	Feb. 22	Calif.-Nevada border	38.5	119.3	8,600	V	4.4
1978	Jan. 13	Southern Nevada near Austin	39.4	117.6	Local	V	4.1
1978	March 5	Northern Nevada near Gabbs	38.9	118.0	Local	V	4.6
1978	May 23	Northern Nevada near Battle Mountain & Valmy	40.9	117.3	-	V	4.6

Source: NOAA, 1973, 1980.



NOTES: DATA PRESENTED ARE THOSE WITHIN A 155 mi. RADIUS OF THE SITE

M – RICHTER MAGNITUDE (THE MAXIMUM AMOUNT OF GROUND MOVEMENT MEASURED AT A FIXED DISTANCE FROM AN EARTHQUAKE'S POINT OF ORIGIN; THE RICHTER SCALE RANGES FROM 1 TO 10).

SOURCE: EXXON MINERALS COMPANY

MT. HOPE MOLYBDENUM PROJECT	
EPICENTER MAP OF EARTHQUAKES WITHIN LAST 50 YEARS	
U.S. Department of the Interior Bureau of Land Management	FIGURE 2-13

Epicenter.--36-1/2° N., 118° W., Owens Valley, near Lone Pine.
Area affected.--Felt strongly over 125,000 square miles. Total area felt unknown.
Intensity.--X-XI
Description.--The Owens Valley earthquake is one of the larger earthquakes in the history of the Basin and Range province. The shock was felt over most of California, and probably most of Nevada and Arizona. It was very destructive in the Owens Valley and severe along the western slopes of the Sierra Nevadas, the Mojave Desert, and the eastern part of the Great Valley of California. The most disastrous effects of the earthquake were at Lone Pine. Of a population between 250 and 300, 27 were killed and about 56 were injured. Of 59 houses, 52 were destroyed, most of which were adobe. At Independence, 9 miles north, the same type of structure was used, but there was little loss of life. At Indian Wells, 67 miles south of Lone Pine, adobe houses were cracked. Near Owens Lake, numerous depressions formed between cracks in the earth. In one place, an area 200 to 300 feet wide sank 20 to 30 feet leaving vertical walls; several long, narrow ponds were formed. There was a disturbance of terrain from Haiwee nearly to Bishop. Well-defined scarps up to 23 feet in height were formed along the fault at the east base of the Alabama Hills and its northerly continuation, and horizontal motion ranging up to 20 feet was revealed by the movement of fences crossing the fault. Large masses of rock were dislodged from steep slopes. There appear to have been thousands of aftershocks, some severe. This shock was greater than those of 1857 and 1906.

Nevada Earthquake of October 2, 1915

Time of occurrence.--22:53*.
Epicenter.--40-1/2° N., 117-1/2° W., Pleasant Valley, Nev.
Area affected.--500,000 square miles.
Intensity.--X at epicenter.
Magnitude.--7.6; acceleration at Mt. Hope = 0.09g (Call and Nicholas, 1982)
Description.--The shock occurred along a fault on the eastern side of Pleasant Valley, which lies south of Winnemucca. It was felt over a larger area than the San Francisco earthquake of 1906 -- from Baker, Oreg., to San Diego, Calif., and from the Pacific coast to beyond Salt Lake City, Utah -- but caused little property damage because the area had few structures and people. There were two foreshocks -- 15:40 and 17:49 -- which were barely felt outside Nevada. There

was a roar at Kennedy, and people found it difficult to remain on their feet. There, the motion continued until the main shock at 22:53. There was a great roar at that time, people were thrown from beds, adobe houses were destroyed, mine tunnels caved in, and concrete mine foundations cracked. Cracks appeared for considerable distances where materials were unconsolidated. At Winnemucca, damage was moderate and generally confined to that part of the city on low ground. At Lovelock, large water tanks were thrown down and cracks appeared in the road. Applications were filed for new water rights because of the great increase in water flow. A rift, with a fresh vertical scarp 5 to 15 feet high and 22 miles long, was formed parallel to the base of the Sonoma Mountains.

Western Nevada Earthquake of December 20, 1932.

Time of occurrence.--22.10*.
Epicenter.--38.7° N., 117.8° W., in the Cedar Mountain District.
Area affected.--500,000 square miles.
Intensity.--X
Magnitude.--7.3; acceleration at Mt. Hope - 0.03 g (Call and Nicholas, 1982).
Description.--Since the region was uninhabited except for an occasional miner or sheepherder, little damage occurred. Two cabins, one of stone and the other of adobe, were destroyed, and mining property was damaged. Many chimneys were thrown down at Mina and Luning. At Hawthorne, the shock cracked cement and threw down additional chimneys.

Extensive and complicated faulting occurred over an area 38 miles long and 4 to 9 miles wide in the valley between the Pilot and Cedar Mountain ranges, northeast of Mina. In this belt, 60 fissures ranging up to 4 miles in length were found, and others undoubtedly were hidden by snow when the survey was made. Boulders dislodged from hillsides in many places. At one point, large masses of coarsely crystalline limestone or marble dislodged and rolled down a hillside. Ground-water flow was either increased or decreased. The shock was felt from the Rocky Mountains to the Pacific Ocean and from San Diego to San Francisco, very noticably at the latter.

Dixie Valley, Nev., Earthquake of December 16, 1954.

Time of occurrence.--03.07*.

Epicenter.--39.3° N., 118.2° W., near Frenchman's Station, Nev.

Area affected.--200,000 square miles.

Magnitude.--7.1; acceleration at Mt. Hope = 0.04 g (Call and Nicholas, 1982).

Intensity.--X.

Description.--This shock was felt in California, Oregon, Idaho, Arizona, and Nevada, and as far east as Salt Lake City, Utah. Intensity X was assigned to the spectacular surface ruptures which occurred in an area roughly bounded by geographic coordinates 39°01' to 39°50' N., 118°00' to 118°15' W. Within this area there are two major fault zones--in the north, on the west side of Dixie Valley along the east base of the Stillwater Range; in the south, on the east side of Fairview Valley in the Clan Alpine Range. Faulting extended north and south for a linear distance of approximately 55 miles. Because the epicentral tract was sparsely populated, this potentially destructive earthquake caused relatively little property damage.

Five to 15 feet of vertical movement and some horizontal displacement occurred in the Dixie Valley Fault zone. Water of about 60° temperature flowed from a fracture at Mud Springs and cut several trenches 2 to 3 feet deep down the slope toward the Dixie Valley Road. Where the fracture ran through more compact sediments, the fissure was several to many feet deep. At IXL Canyon, about 2 miles north of Mud Springs, there were large vertical displacements and a 55-foot graben. In the settlement of Dixie Valley and vicinity, all wells increased in flow, new wells formed, and water bubbled from the ground in spots. An adobe cellar, a stone wall, and gasoline and water tanks collapsed. Largest movements were observed at the eastern base of Chalk Mountain, Fairview Peak, and Slate Mountain. Vertical movement varied between 3 and 6 feet where the fault zone crossed U.S. Highway 50, south of Chalk Mountain. The highway was badly cracked. East of Fairview Peak, there were movements of 6 to 20 feet and horizontal displacements of 4 to 12 feet. Several rocks of automobile size fell onto the highway west of Carroll Summit. At Frenchman's Station, heavy furniture was displaced but damage to buildings was negligible. A ground crack extended beneath a store, raising the southeast side about 4 inches. One well decreased in flow and water became cloudy. Damage at Fallon was limited to a

few toppled chimneys. Chimneys twisted and fell at Austin. At Sacramento, Calif., the shock caused an estimated $20,000 damage to a water tank. A magnitude 6.8 aftershock occurred at 03:11; acceleration at Mt. Hope = 0.03 g.

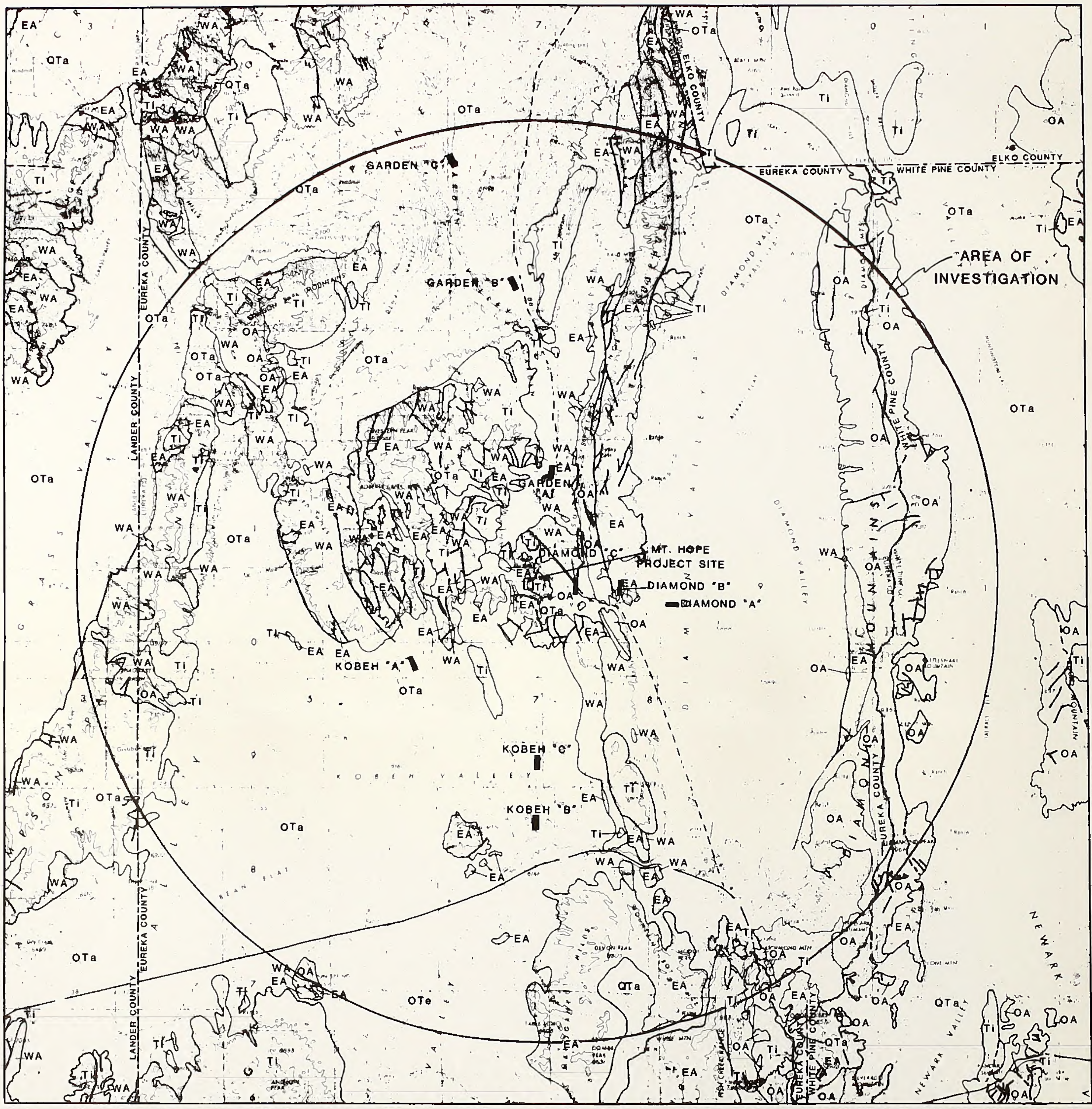
2.7.3 Seismicity at Mt. Hope

The interior areas of the Great Basin, which the Mt. Hope area is part of, have experienced relatively little recent historic seismicity (Smith and Sbar, 1974). Historic surface faulting and seismicity has centered on the Ventura-Winnemucca Zone of west-central Nevada.

The faults in the Mt. Hope area are of two types: 1) Those formed during the Antler Orogeny of Devonian and Mississippian age (Roberts Mountains Thrust) and, 2) Basin and Range faulting of Cenozoic age (Tertiary and Quarternary) involving high angle normal faulting and tilting of Basin and Range blocks accompanied by igneous intrusion. Faulting within a 25 mile radius of Mt. Hope is shown in Figure 2-14 and site specific fauling is shown in Figures 2-15 and 2-16.

The low angle fault along the Garden Valley-Vinini contact of Mt. Hope is associated with the Roberts Mountain Thrust. Other minor faults of Mt. Hope may be associated with this event, however, the numerous high angle faults and the arc-shaped normal Mt. Hope and Ravine Faults are associated with the Tertiary igneous intrusive episodes of the Mt. Hope suite, as well as the Mt. Hope Spring Fault and the Upper and Lower Lorraine Faults.

The Mt. Hope area is considered a Zone 2 seismic risk area, with a definition as a zone in which moderate damage could be expected as a result of earthquake activity (NOAA 1973). The immediate area around Mt. Hope however appears to be relatively quiet seismically. Although minor faults previously mentioned in the site area may be potential sources of earthquakes, Wallace (1981) has identified the site within a region where no large fault scarps have broken the surface for more than 500,000 years.



Geology modified from: Roberts and others, 1987, Hose and others, 1976, Mabey 1964, Stewart and others, 1977. Base: U. S. Army Topographic Command, Millett, Ely, Elko, and Winnemucca, Nevada Topographic Contour Interval: 200 teet (61.0 metere)

EXPLANATION

Source: Hydro-Search, Inc., 1982

Paleozoic — Mesozoic — Cenozoic (Tertiary, Quaternary)

OTa — Alluvium

Ti — Tertiary volcanica and intrusivas, unditterentiated

OA — Ovarlap Aaaambiaga; dominently conglomarata, aandatona, end shale with minor limaatona, undittarantiatad

WA — Wastarn Aaaambiaga; dominataly ahala, chart, quartzita, and andaaitic volcanic rocka, undittarentlatad

EA — Eastern Assembiaga; dominantly limastona and dolomita, unditfarantiatad

N

Gaologic Contact

Fault, deahad whare locatfon approximeta

Thrust Feult, teeth on uppar piete

Wall Flald Location — KOBEH "A"

0 5.0 10.0 15.0 Kilometers

0 5.0 10.0 15.0 Miles

1:250,000

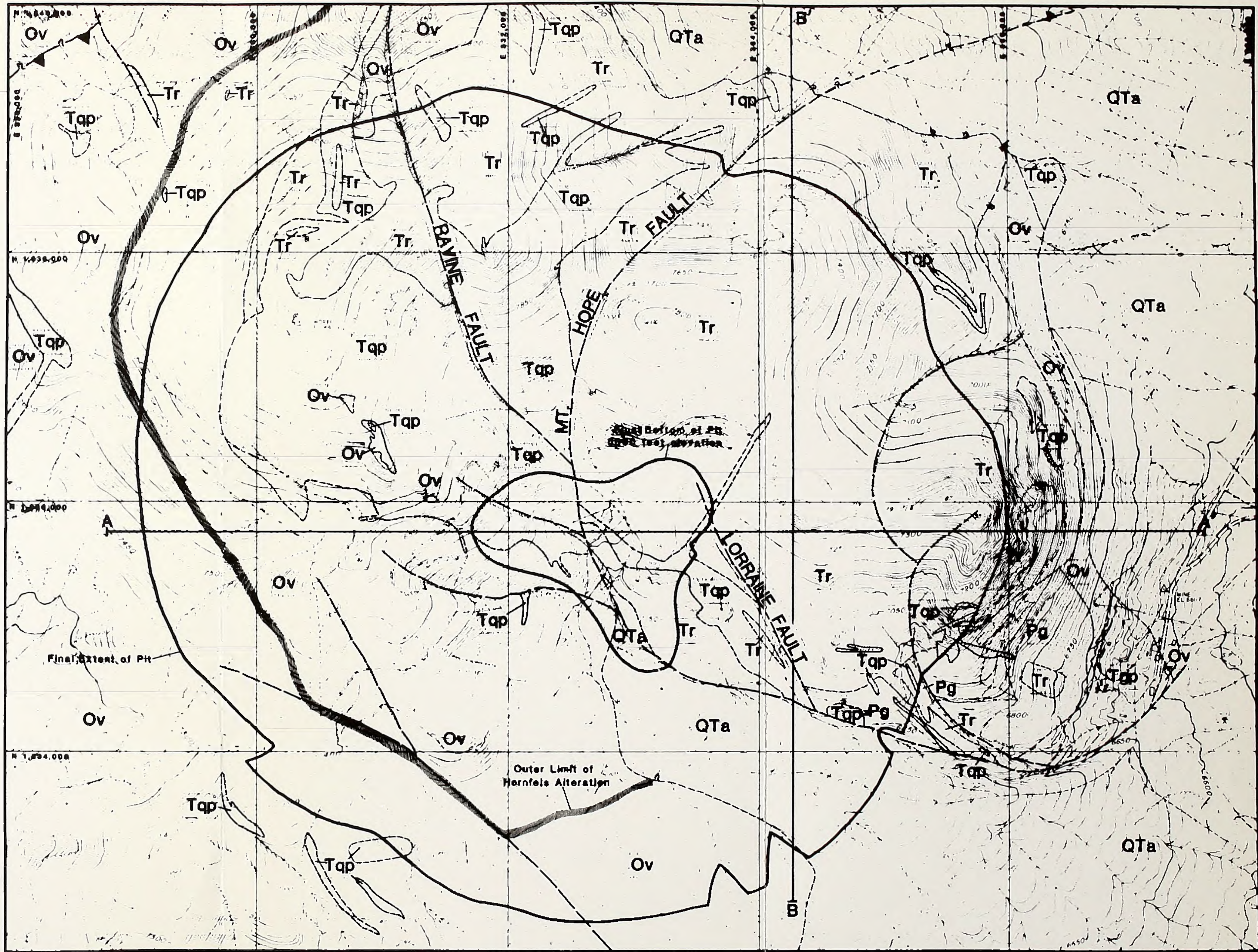
MT. HOPE
PHASE I HYDROLOGY

MT. HOPE MOLYBDENUM PROJECT

GENERALIZED REGIONAL GEOLOGY AND FAULTS

U.S. Department of tha Interior
Bureau of Land Management

FIGURE 2-14



Geology modified from Exxon Minerals Company, G. Westra and K.A. Riedell, 1981
Conceptual final pit configuration supplied by Exxon Minerals Company

Map generated by Hydro-Search, Inc., 1982.

Contour Interval: 10 feet
(3.028 meters)

0 100 200 300 meters — 0 400 800 1200 feet

1:4800

EXPLANATION

QTa - Alluvium

Tgp - Granodiorite porphyry

Tqp - Quartz porphyry

Tr - Rhyolite

Pg - Garden Valley Formation (included in OA of Fig. 2-14)

Ov - Vinini Formation

Geologic contact, dashed where approximate, queried where inferred ———?—

Normal fault, dashed where approximate, queried where inferred ———?—

Thrust fault, approximate, teeth on upper plate —▲—

Cross Section A——A

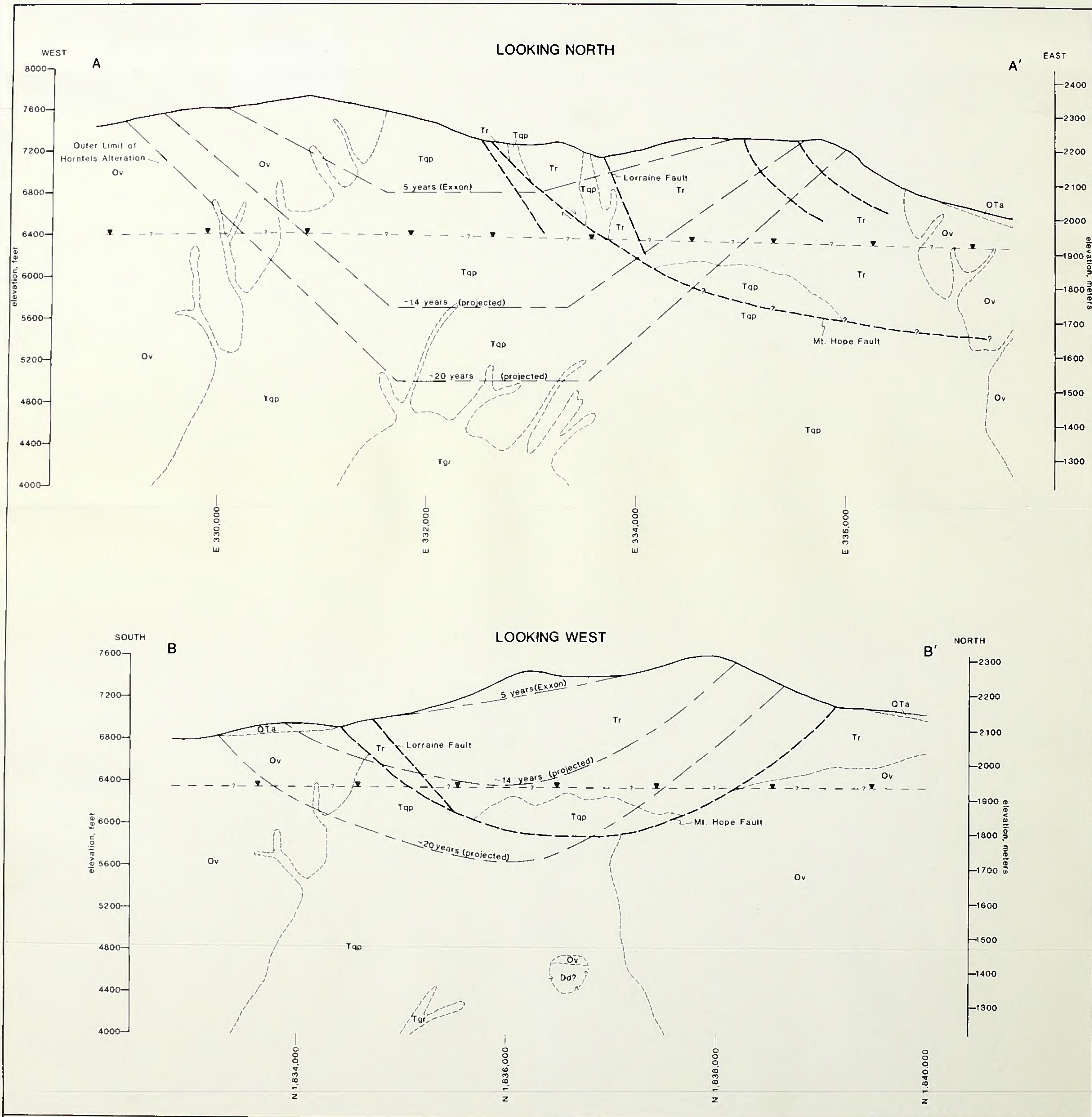
MT. HOPE
PHASE I HYDROLOGY

MT. HOPE MOLYBDENUM PROJECT

GENERALIZED GEOLOGY AND FAULTS IN THE VICINITY OF THE MINE SITE

U.S. Department of the Interior
Bureau of Land Management

FIGURE 2-15



EXPLANATION

QTa - Alluvium

Tgr - Granite

Tqp - Quartz porphyry

Tr - Rhyolite

Dd - Eastern Assemblage carbonates

Ov - Vinini Formation

Geologic contact, approximate

Fault, approximate, queried where inferred

Estimated ground-water level

Pit outline, approximate

Source: Hydro-Search Inc. 1982, modified from Exxon Minerals Company

Horizontal Scale: 1 inch = 400 feet
Vertical Scale: 1 inch = 400 feet
No Vertical Exaggeration

Lines of cross sections are shown on Figure 7-3

0 100 200 300 meters — 1:4800 — 0 400 800 1200 feet

PLATE

MT. HOPE
PHASE I HYDROLOGY

MT HOPE MOLYBDENUM PROJECT

GENERALIZED HYDROGEOLOGIC CROSS SECTIONS IN THE VICINITY OF THE MINE SITE

U.S. Department of the Interior
Bureau of Land Management

FIGURE 2-16

2.8 Economic Resources

2.8.1 Mineral Resources/Industry of Nevada

The chief economic resources of Nevada lie in its significant mineral deposits. Mining is the second largest economic activity, next to the gaming industry.

More than 200 economically valuable metallic elements and minerals are known to exist in Nevada. The total value of nonfuel mineral production in Nevada was $504 million in 1981, an increase of 28% over that of 1980. However, the 1982 figures are lower due to decreased values, mine shut downs and deep cuts into company operating budgets and staffs. The estimated value of Nevada's mineral production for 1982 was just under $477 million, as based on preliminary nonfuel estimates by the U.S. Bureau of Mines (see Table 2-3). Nevada ranked 14th among the states in nonfuel mineral production.

Even with the considerably lower-level of exploration, Nevada has more exploration underway than other states, mainly due to the interest in and potential for gold ore discoveries. The U.S. Bureau of Land Management reported that more claims were filed in Nevada than in any other western state. However,-Nevada had only one new mine opening and two mine reopenings in 1982.

In 1978, for the first time in over 50 years, gold replaced copper as the state's leading mineral commodity, accounting for $269.5 million, or 54% of the total mineral value produced in the state for 1982. Nevada was the leading gold producer in the Nation, accounting for 49% of the total produced in 1982. Nevada is also the Nation's leading producer of barite, magnesite and mercury (see Table 2-4).

Twenty-five mineral commodities are produced in the state; 10 metals, 15 nonmetallics and mineral fuel. The metals produced are: gold, copper, iron ore, lead, mercury, molybdenum, silver, titanium, tungsten and zinc. The non-metallics produced are: barite, cement, clays, diatomite, fluorspar, gem stones, gypsum, lime, lithium compounds, magnesite, brucite, perlite, salt,

Table 2-3 Nevada's Mineral Production 1/

Mineral	Unit	1981 Quantity	1981 Value (thousands)	1982P Quantity	1982P Value (thousands)
Barite	thousand short tons	2,482	$ 79,716	1,765	$ 56,158
Clays	thousand short tons	73	2,948	110	4,604
Gemstones			1,000		1,000
Gold	troy ounces	524,802	241,220	679,700	269,535
Gypsum	thousand short tons	778	6,914	758	7,073
Iron ore	thousand long tons	99	1,490	W	W
Mercury	76-pound flasks	27,819	11,514	25,000	10,000
Petroleum	thousand 42-gallon barrels	699	18,900	597	17,900
Sand and gravel	thousand short tons	6,000	12,800	7,000	14,500
Silver	thousand troy ounces	3,039	31,970	254	2,032
Stone, crushed	thousand short tons	1,343	5,664	1,240	3,800
Combined value of cement, copper, diatomite, fluorspar, iron ore (1982), lead, lime, lithium compounds, magnesite, perlite, salt, sand (industrial), tungsten, and zinc			108,413		108,242
Total			$522,549		$494,844

1/ Production as measured by mine shipments, sales, or marketable production (including consumption by producers), as compiled by U.S. Bureau of Mines (Mineral Industry Survey, Nevada -- 1982) except for petroleum.

P Preliminary.

W Withheld.

Source: Nevada Bureau of Mines & Geology. Special Publication MI, 1982.

Table 2-4 Nevada's Role in U.S. Mineral Supply in 1982

Commodity	Share of U.S. output (percent)	Rank in Nation
Barite	89	1
Diatomite	*35	2
Fluorspar	*1	3
Gemstones	15	2
Gold	49	1
Gypsum	7	7
Lithium	*40	2
Magnesite	*100	1
Mercury	*99	1
Silver	1	9
Tungsten	*15	3

*Estimated by Nevada Bureau of Mines and Geology.

Source: U.S. Bureau of Mines.

sand and gravel. Table 2-5 shows the value of nonfuel mineral production in Nevada by County.

Nevada has the only active magnesite mine in the U.S. and is the second largest diatomite, gemstone and lithium producing state. Industrial mineral production in 1982 for Nevada was down $30 million (15%) from the record year in 1981. Estimated value for 1982 was $166 million. The decrease was mostly a result of less tonnage and the falling value of barite. Barite (value at $56 million), diatomite, cement, and lithium carbonate were the highest value industrial-mineral commodities for 1982.

Geothermal resource exploration was also down considerably in 1982, as compared to 1981 figures. Only four large-diameter wells were drilled for a total footage of 25,624 ft., being only about 30% of the 1982 level (see Table 2-6).

Oil and gas exploration during 1982 involved 12 wells totaling 103,250 ft (see Table 2-7) a 35 percent decrease from 1981. The nationwide decrease was approximately 7 percent. However, the number of federal oil and gas leases increased by more than 10 percent and the average depth of wells drilled increased from 5,736 to 8,605 feet. Oil production for 1982 was 596,510 barrels (value of $17.9 million), a decrease of 14.7% from 1981 (see Table 2-8). Amoco Production Co. completed a new field discovery in Pine Valley, Eureka Co. in which two pay zones were reportedly completed.

2.8.2 Mineral Resources/Exploration in Eureka County.

The minerals produced in Eureka County, in order of value, are gold, iron ore, silver, stone, barite, sand and gravel, lead, mercury, copper and zinc.

Nonmetallic deposits have become increasingly important and the county has substantial reserves of barite and diatomite. There are 17 mining districts within the county. The following discussion of mineral resources in Eureka County is directly from the Nevada Bureau of Mines Bulletin 64 by Roberts, Montgomery and Lehner (1967). Some of the data may be outdated, however, a good

Table 2-5 Value of Nonfuel Production in Nevada, by County (Thousands)

County	1978	1979	1980	Minerals produced in 1979, in order of value
Carson City	$252	W	$409	Stone, sand, and gravel
Churchill	W	$1,903	W	Diatomite, sand and gravel, salt, gold, silver, tungsten, copper, lead, zinc
Clark	38,199	36,779	37,178	Sand and gravel, lime, gypsum, stone, silver, copper, gold, tungsten
Douglas	W	1,488	W	Sand and gravel, silver, gold, stone
Elko	W	6,427	17,098	Barite, copper, gold, silver, sand and gravel, tungsten, stone
Esmeralda	15,836	17,917	21,591	Lithium, diatomite, silver, gold, clays, talc, tungsten
Eureka	30,674	40,864	W	Gold, iron ore, silver, stone, barite, sand and gravel, lead, mercury, copper, zinc
Humboldt	4,075	8,526	12,089	Mercury, stone, sand and gravel, clays
Lander	30,423	49,082	87,335	Gold, barite, copper, silver, sand and gravel
Lincoln	8,969	12,131	13,282	Tungsten, gold, lime, silver, sand and gravel, perlite, clays
Lyon	37,538	25,254	27,695	Cement, stone, sand and gravel, gypsum, diatomite, silver
Mineral	W	40	6,468	Silver, gold, tungsten, sand and gravel
Nye	20,259	22,492	45,566	Gold, barite, magnesite, clays, sand and gravel, silver, fluorspar, stone
Pershing	14,295	17,731	18,495	Diatomite, gypsum, iron ore, sand and gravel, stone, perlite, gold, silver, clays
Storey	7,924	12,389	21,043	Silver, gold, diatomite, sand and gravel
Washoe	W	4,659	2,793	Sand and gravel, stone, clays, silver, gold
White Pine	W	W	W	Sand and gravel, tungsten, stone
Undistributed 1/ ...	28,965	2,567	83,186	
Total 2/	$237,408	$260,249	$394,230	

W Withheld to avoid disclosing company proprietary data; included with "Undistributed."
1/ Includes some sand and gravel (1980) that cannot be assugned to specific counties, gemstones, and values indicated by symbol W.
2/ Data may not add to totals shown because of independent rounding.

Source: U.S. Bureau of Mines

Table 2-6 Large-Diameter Geothermal Wells Drilled in Nevada in 1982

Company name	Well name	Depth	Location	County
			Dixie Valley	
Rosewood Corp.	Eleven Mile Canyon No. 52-14	8,246'	S14,T19N,R34E	Churchill
Rosewood Corp.	Pirouette Mountain No. 55-16	7,379'	S16,T19N,R34E	Churchill
			Desert Peak	
Phillips Petroleum Corp.	Desert Peak 86-21	3,269'	S21,T22N,R27E	Churchill
Phillips Petroleum Corp.	Desert Peak 22-22	6,730'	S22,T22N,R27E	Churchill

Source: Nevada Bureau of Mines and Geology, Special Publication MI-1982, 1983.

Table 2-7 Oil and Gas Wells Drilled and Completed During 1982

Company	Well	Permit No.	Total Depth	County
Amoco Production Co.	Big Pole Creek No. 1	323	8,300	Eureka
Amoco Production Co. 1/	Blackburn No. 3	324	7,955	Eureka
Grace Petroleum Corp.	Arrow Canyon No. 1	329	17,100	Clark
Sun Oil Co.	Southern Pacific No. 1	330	14,000	Elko
Cities Service Co.	Federal BL No. 1	332	10,045	Elko
Amoco Production Co.	Blackburn No. 4	333	8,100	Eureka
Amoco Production Co.	Blackburn No. 6	335	7,651	Eureka
Sun Exploration & Production Co.	Southern Pacific No. 3-13	342	10,936	Elko
Buckhorn Petroleum Co.	Adobe Federal No. 16-1	343	3,945	Nye
Jayhawk Exploration, Inc.	Federal-Indian Springs No. 1	344	5,583	Clark
Buckhorn Petroleum Co.	Chuckwagon Federal No. 10-14	345	7,000	Nye
Texaco, Inc.	Munson Ranch No. 11-34X	346	2,635	Nye

1/ Producing well.

Source: Nevada Bureau of Mines & Geology. Special Publication MI - 1982

Table 2-8 Nevada's Oil Production 1/

	1981		1982	
Field (Discovery Data)	Year	Cumulative	Year	Cumulative
Eagle Springs (1954)	72,441	3,531,416	48,967	3,580,383
Trap Spring (1976)	599,907	4,197,192	495,907	4,693,099
Currant (1972) 2/	-	635	-	635
Bacon Flat (1981)	27,331	27,332	37,408	64,740
Blackburn (1982)	-	-	14,228	14,228
	699,679	7,756,575	596,510	8,353,085
			14.7% decrease	

1/ Production (in 42-gal. barrels) as reported by oil producers to the Nevada Division of Mineral Resources.

2/ The Currant Field produced 635 barrels of oil in 1980 from its single well before it was shut in. The cost of diluting the thick oil to produce it was too high to make production economically feasible.

Source: Nevada Bureau of Mines & Geology. Special Publication MI - 1982

account of mineral deposits is given. A section on current mining and exploration will follow.

Metallic Minerals. Metallic minerals in Eureka County occur in four principal geologic settings:

1. Deposits in carbonate rocks: gold-silver, lead-zinc-silver, silver-lead veins, manganese-nickel, and antimony.
2. Deposits in chert and shale: gold-copper, quicksilver, and vanadium deposits.
3. Deposits in volcanic rocks: iron, and silver-lead veins.
4. Placer deposits: gold.

Deposits in Carbonate Rocks. Deposits in carbonate rocks commonly are related to intrusive bodies of igneous rock. The ore generally occurs in or near fracture systems that may be pre-intrusive or related to the intrusion. Such deposits are in the Eureka, Cortez, Roberts, and Lynn districts. It has been noted (Roberts, 1957, p. 5; 1960a; 1964a,c; 1966) that these districts are in windows of the Roberts Mountains thrust plate and that they are aligned northwestward. The windows represent upwarps possibly formed over deepseated basement structures.

Gold-silver deposits. Gold-silver deposits in carbonate rocks have yielded a significant production in the county. They occur mainly in the Eureka district and are on the periphery of the main lead-zinc producing area. The deposits are characterized by simple sulfide mineralogy, chiefly pyrite, which is commonly oxidized on the upper levels to limonite and hematite. Most production has come from the oxidized ores; sulfide ores generally have been too low in grade for profitable operation.

Lead-zinc-silver deposits. Lead-zinc-silver deposits have been the most productive in Eureka County. During the early days of the Eureka district, silver-rich oxidized ores accounted for most of the production, but lead was also important, and some deposits contained as much value in gold as in silver. During World War II, base metals were important, but in the future gold from ore bodies of the Carlin type probably will dominate mineral production in the county.

The ore bodies are irregularly shaped, tabular, lenticular, and chimney-like bodies that range from a few feet to several hundred feet in dimension. Ore produced on Ruby Hill, in the Eureka district, between 1871 and 1891 ranged in value from $30 to $300 a ton with an average value of $50 to $60 (Vanderberg, 1936, p. 37). Of this average, lead amounted to about $20, gold to about $14, and silver about $22.

Silver-lead veins. Silver-lead veins have been mined in the Antelope, Cortez, and Diamond districts. The veins consist of pyrite, galena, sphalerite, tetrahedrite, and other sulfides; the principal value generally is in silver. Most of the veins are narrow, and production has been small; but some highgrade shoots have been found, principally in the oxidized zone.

Manganese-nickel deposits. The Gibellini mine in the Fish Creek district is in limestone that contains an ore body composed of manganese oxides with secondary zinc and nickel minerals.

Antimony deposits. Antimony prospects have been explored in shallow workings in the Antelope district. The deposits consist of small masses of stibnite and stibiconite, a hydrated oxide of antimony, in shear zones in limestone.

Deposits in Chert and Shale. Ore deposits in chert and shale of the western assemblage include gold-copper deposits near the Roberts Mountains thrust and barite deposits within the upper plate. Gold-copper deposits in these rocks have not yet yielded large production in Eureka County, but in nearby parts of Elko and Lander Counties such deposits have notable production.

Gold-copper deposits. Gold-copper deposits in Eureka County include the Cooper King and Number Eight mines in the Lynn district, which occur within or near the Roberts Mountains thrust fault. The gold-copper metallization occurs in crushed and sheared zones along the thrust.

Vanadium deposits. Vanadium deposits occur in black marine phosphatic shale of Devonian Age near the Gibellini mine on the east flank of the Fish Creek Range (Davis and Ashizawa, 1958). These shales in Eureka county are

mostly in the frontal part of the Roberts Mountains thrust plate and represent a transitional facies that was originally deposited west of Winnemucca (Roberts et al, 1958, p. 2817); Ordovician shales of the transitional assemblage near Golconda, 15 miles east of Winnemucca, also are vanadiferous (Davidson and Lakin, 1961b), which suggests that the environment in which this assemblage was deposited was favorable to the accumulation of vanadium. Enrichment may have taken place during diagenesis and later during weathering.

Vanadiferous shales also occur in Mississippian units of eastern Nevada and western Utah (Davidson and Lakin, 1961b). These deposits may have been derived from the Devonian vanadiferous shales and transported eastward by powerful currents, such as density currents. In this way transport could be accomplished without significant dilution.

Deposits in Volcanic Rocks. Deposits in volcanic rocks include iron deposits and silver veins in the north end of the Cortez Mountains. The iron deposits have yielded more than one million tons of ore, mined partly for flux and partly for iron ore. The silver veins have yielded only a small production; they are similar to the silver veins in carbonate rocks and in part may have formed at the same time.

Iron deposits. The iron deposits at the Barth mine in the Safford district and in the Modarelli-Frenchie Creek district occur near the contacts of intrusive bodies and replace volcanic rocks along bedding planes and faults (Shawe, Reeves, and Kral, 1962).

Silver veins. Silver veins in the Safford district occur in andesite. Most of the veins are narrow and nonpersistent, but some ore has been mined and shipped. The primary minerals are tetrahedrite, pyrite, galena, sphalerite, and other sulfides in a gangue of quartz, barite, and mangano-calcite.

Placer Deposits

Gold. Placer deposits in the Lynn district have yielded a small but persistent production of placer gold in Lynn, Sheep, and Rodeo Creek Valleys (Vanderburg, 1936, p. 49-53). The gold apparently is derived from mineralized shear zones in the upper plate of the Roberts Mountains thrust zone and from fault zones that cut carbonate rocks below. Placer deposits in Maggie Creek also are credited with a small production.

Nonmetallic Minerals

Nonmetallic minerals contributed comparatively little production during the early days of mining in Eureka County, but salt from Diamond Valley was used in the chlorination process for recovery of silver during the 1870's. More recently, production of barite has been significant, and exploration for petroleum has been carried on at several places. Deposits of materials useful in the construction industry are widely distributed throughout the county; they are principally quarried by County and State agencies for use on roads. Rock also is quarried for use as track ballast by a contractor for the Southern Pacific Railroad.

Deposits of limestone and dolomite in Eureka County are widespread, and may be of future value in industrial processes. The Eureka Quartzite, which crops out in the southern part of the Lynn district and in other parts of the county, likewise may become a valuable resource.

Deposits of perlite are reported in eastern Eureka county near Carlin; no production has been reported (Gemmill, 1964, map, p. 235). Pumicite deposits southwest of Carlin in sec. 25 , T. 32 N., and R. 51 E. have been mined intermittently (Vanderburg, 1938, p. 58; Horton, 1964b, p. 240).

Asphaltite. According to Anderson (1908), veins of asphaltite cut sandstone and shale on the east side of Pine Valley about 15 miles south of Palisade. The veins strike N. 75° W. and dip 50°-60° NE., and are as much as 16 inches wide.

Prof. Walter S. Palmer at the Mackay School of Mines laboratory, Reno, Nev., analyzed specimens of the asphalitite and found that it contained vanadium (Vanderburg, 1938, p. 57).

Barite deposits have been noted in the Maggie Creek and Alpha districts (Horton, 1962; 1964a, p. 177-179) and a number of other localities in the county. The Maggie Creek mine, which has been described by Vanderburg (1938, p. 64), is in the E1/2 NE1/4 sec. 27, T. 34 N., R. 51 E., on the west side of Maggie Canyon. Massive barite occurs in a vein in shaly limestone that strikes S. 30° E., dips 70° E., and averages 10 feet in width. Impurities are iron oxides and silica. Total production is over 10,000 tons with a specific gravity of 4.2 (Horton, 1962). On the south end of the Good Hope group of claims is a vein that was mined by the Industrial Minerals and Chemical Co. of Berkeley, Calif., in 1935-36 (Vanderburg, 1938, p. 64). Three veins have been explored; the main vein strikes N. 25° W. and dips 75° NE.; along the vein, stopes are as much as 20 feet wide and 40 feet high in fractured chert and limestone. The barite filled fractures for the most part but locally replaced limestone.

The Alpha prospect (Horton, 1962) is at the Old Whalen mine, in the SW1/4 sec. 34, T. 25 N., R. 52 E. Deposits also have been noted in the Lynn district (Gianella, 1940, p. 298) and at the Bear mine in the Union district.

Diatomaceous Earth. Diatomaceous earth deposits have been reported (Vanderburg, 1938; Olson, 1964a, p. 191) in the hills "several miles north and northwest of Palisade." The deposits are said to be extensive, and claims have been staked on them, but to date there has been very little production. Diatomite beds have also been mapped in Tertiary sediments on the south side on Lone Mountain (C. W. Merriam, oral communication, 1958).

Petroleum. Exploratory drilling for oil has been carried on sporadically in Eureka County for several years. The first interest was in the vicinity of a live oil seep in sec. 11, T. 27 N., R. 52 E., on the Bruffey Ranch. The oil presumably rises from the Vinini Formation along a north-south fault that can be traced for several miles on the surface. The site was first drilled in the spring of 1951 (Lintz, 1957a, p. 42). Since then a number of holes have been drilled in the area by the Eureka Oil Co.

and the Eureka Leasing and Drilling Co., but oil has not been reported (Lintz, 1957a, p. 42; Grace M. Nolan, written communication, 1959). The Last Frontier No. 1 Damele well, sec. 6, T. 26 N., R. 51 E., was abandoned in 1957 (National Oil Scouts and Landmen's Assoc., 1958), although shows of oil were reported in Tertiary rock; total depth at the end of 1956 was 3,500 feet (Lintz, 1957b, p. 245). The Shell Oil Co. No. 1 Diamond Valley well was abandoned in 1956 at a total depth of 8,042 feet (Lintz, 1957b, p. 245); the top of Paleozoic rock was logged at 7,485 feet (Johnson, 1959, p. 152); oil was not reported.

Along Vinini Creek and at other localities in the Roberts Mountains, Merriam and Anderson (1942, p. 1696) noted that the upper part of the Vinini Formation contains black organic shales that can readily be ignited; oil yield on distillation of selected samples was above 25 gallons per ton. The possibility of oil accumulation in fault traps within thrust plates in this area is recognized, but structural complexity has discouraged exploration.

Salt. The northern end of Diamond Valley is a playa that becomes a shallow lake following rainstorms and heavy run-off in the spring; normally the water stands a few feet below the surface. The surface is encrusted with salts containing about 60 percent NaCl, and the muds are saturated with brine, reported by Whitehill (in Vanderburg, 1938, p. 65) to contain about 12 percent salt.

These deposits were worked during the 1870's for salt used in the chloride process of silver extraction from oxidized ores at Eureka, Mineral Hill, and Hamilton (White Pine County). The salt was at first obtained by collecting the surface incrustations, but later evaporating pans were installed, which had a capacity of 5,000 pounds of salt daily (Lincoln, 1923, p. 89; Horton, 1964c, p. 253).

Sulfur. Sulfur deposits at Hot Springs Point in NE1/4 sec. 11, T. 29 N., R. 48 E., about 10 miles southeast of Beowawe, have been explored during recent years but no production, except for mineral specimens, has been recorded. The rocks in the area are mainly quartzite, shale, and chert of the Valmy Formation which, half a mile to the north, are overlain by basaltic or andesitic flows of Tertiary Age.

The sulfur, associated with gypsum and iron oxides, forms veins and breccia filling sporadically distributed in fractured and altered rock along a northeast-trending range-front fault. Hot springs, which apparently rise along the same or parallel faults, emerge just northwest of the area. The deposit has been explored by shallow cuts and short adits. Small amounts of cinnabar and antimony oxides occur in the deposit (Olson, 1964b, p. 257).

2.8.2.1 Recent Exploration/Mining in Eureka County

More recent exploration and mining in Eureka County is described below.

Nevada-Barth Corp. in Eureka County was the state's largest iron ore shipper in 1981. Carlin Gold Mining Co. of Eureka and Elko Counties is the principal gold producer of the state. NL Industries, Inc. of Eureka County is a major barite producer.

Universal Gas Co. of Montana began developing a gold property during 1981 in northern Eureka County. More than 100,000 tons of gold ore were mined in 1981.

Pan Cana Resources performed exploratory drilling for gold in the Lynn District of Eureka County during 1982.

Newmont Mining Corp. acquired all the property necessary for the development of its Gold Quarry deposit in northern Eureka County late in August, 1982. The purchase of land and mineral rights totaled $34.75 million. The deposit contains reserves of approximately 8 million oz gold. Newmont's Elko Land and Livestock Co. subsidiary bought the 223,000-acre T Lazy S Ranch, including mineral interests owned by the ranch. The ranch encompasses the company's Carlin, Bootstrap, Bluestar, and Maggie Creek Mines. Newmont's Carlin Gold Co. separately bought a 10% interest in the mineral rights to the Gold Quarry property and entered into a new long-term lease of the remaining rights. Production is planned at 120,000 oz gold/year starting in 1985 or 1986. (Mining Congress Journal, Nov. 1982).

Cortez Gold Mines, a joint venture of Placer Amex Inc., Webb Resources Inc. (a wholly owned subsidiary of Standard Oil of Ohio), Bunker Hill Co., and Vernon F. Taylor, Jr., plans to begin production at its Horse Canyon gold deposit in mid-1983. The deposit is in Eureka County, 4 miles northeast of the Cortez mill. Reserves are estimated at 3.4 million short tons with a recoverable grade of 0.055 oz gold/ton. Mining is planned at 2,000 tons of ore/day with an annual production of 40,000 oz gold. Open-pit methods will be used. Over $7 million will be spent to bring the mine into production. About 135 persons will be employed. (Elko Daily Free Press, 8 Nov. 1982).

Cordex reportedly has reserves of 2.3 million metric tons averaging 0.11 oz gold/metric ton at its Boulder Creek property near the Bootstrap Mine in northern Eureka County. (Mine Development Monthly, 19 Nov. 1982).

Amoco Production Co. drilled four wells (over 30% of the 1982 footage in oil and gas exploration) in Eureka county and completed a new field discovery, the Blackburn No. 3 (S8,T27N,R52E), in April 1982. The well is located in Pine Valley, approximately 45 miles southwest of Elko and 5 miles west of the Bruffey oil seep. Little information has been released concerning the well, but two pay zones were reportedly completed. The interval between 770 and 7,199 ft was reported to be a favorable zone during drill-stem tests. It is rumored that the productive zone is in Paleozoic rocks, possibly Mississippian or Devonian dolomite. Production (flowing well) through December 1982 has been 14,228 barrels of oil. The API gravity ranges from 27° to 29.9°. The pour point of the oil is reported to be 30°F (Oil and Gas Journal, 28 Feb. 1983, p. 123).

Working interest owners until payout are Amoco and Getty Oil Co., each with 50 percent interest. After payout, working interest owners will be Amoco, Getty, and North Central Oil Corp., each with one-third interest (Nevada Mining Association Bulletin, Mar.-Apr. 1982).

Following the discovery, Amoco drilled two dry holes in the surrounding sections and has filed for permits to drill three additional wells in the area.

NORNEV Demonstration Geothermal Co., a consortium of electric utilities (Sierra Pacific Power Co., Sacramento Municipal Utility District, Eugene Water

and Electric Board, and Pacific Power and Light) has put their plans on hold for a 10-megawatt binary geothermal power plant at Beowawe (Oregon Institute of Technology Geo-Heat Center Bulletin, Summer/Fall 1982). The project is currently awaiting the outcome of two Federal government reviews (Energy Lines, Sierra Pacific Power Co. Newsletter, Winter 1982).

Hecla and Cyprus dropped their joint venture option at the Ruby Hill Mine south of Eureka in Eureka County. Reserves reportedly are 2.8 million metric tons averaging 0.176 oz gold and 6.23 oz silver/metric ton, as well as 3.7 percent lead and 8.3 percent zinc. (Mine Development Monthly, 19 Nov. 1982).

Western-Windfall Ltd. announced that the Windfall gold mine, near Eureka, Eureka County, had been placed on standby. Thirty-two employees were laid off. Leaching will continue. (Nevada Mining Association Bulletin, Mar.-Apr. 1982).

2.8.2.2 Eureka County Mine Operations Active During 1982

The following section has been abstracted from a directory by Keith G. Papke, as it appeared in The Nevada Mineral Industry, 1982 (Nevada Bureau of Mines and Geology, Special Publication M1-1982). The directory excludes sand and gravel.

EUREKA COUNTY*	Commodity/Process Type/Ave. Employment
Barite Mining, Inc. Lakes Mill S3,T34N,R51E	barite (gravity concentration) 13
Carlin Gold Mining Co. Blue Star Mine S4,T35N,R50E	gold 2
Carlin Mine S14,T35N,R50E	105
Carlin Mine S14,T35N,R50E	(cyanidation) 92

*Compiled in part from information supplied by the staff of the Division of Mine Inspection, Department of Industrial Relations.

Gold Quarry & Maggie Creek Mines S29,35,T34N,R51E	51
General Mineral Development Co. Eureka-Hamburg Mine S22,T19N,R53E	gold & silver (cyanidation) 8
H & H Construction Queen Ann Mine S12,T34N,R51E	barite 2
IMCO Services, Inc. Beowawe Loading Facility S6,T31N,R49E	barite 2
Lloyd C. Evans Construction Co. Bullion Monarch Mine S10,T35N,R50E	gold 14
Nevada Barth Corp. Nevada Barth Mine S7,8,T31N,R51E	magnetite (iron ore) (crushing, screening) 3
NL Industries, Inc., Baroid Div. Dunphy Mill S26,T33N,R48E	barite (flotation) 46
TRV Exploration (Nevada), Inc. Geddes Mine S28,T18N,R53E	silver (heap leach) 5
Unichem Minerals, Inc. Coyote Mill S3,T34N,R51E	barite (gravity concentration) 4
Universal Gas (Montana), Inc. Bullion Monarch Mine (OP,ML) S10,T35N,R50E	gold (cyanidation) 26
Western States Minerals Corp. Gold Strike Mine S31,T36N,R50E	gold (heap leach) 11
Western-Windfall, Ltd. Windfall Mine (OP) S2,T18N,R53E	gold (heap leach) 30

2.8.3 Mt. Hope Mining District

The Mt. Hope mining district came into being in 1870, when zinc-lead replacement ores in the altered Permian limestones of the Garden Valley Formation were discovered. The only productive property in the district has been the Mt. Hope mine itself. A description of the district and mine is taken from the Nevada Bureau of Mines Bulletin 64 (1967), as follows:

"The Mount Hope district is on the southeast side of Mount Hope in the unsurveyed portions of T. 22 N., Rs. 51 and 52 E., 21 miles north of Eureka and 57 miles south of Palisade, Nevada State Highway 20 passes within a mile and a half of the main workings.

The district is in chert and shale of the Vinini Formation and conglomerate and limestone of the Garden Valley Formation. These rocks have been intruded by a rhyolite plug that forms Mount Hope.

Lead-zinc minerals were first discovered in this area in 1870 by Basques, who operated charcoal furnaces at Eureka.

The Mount Hope mine consists of workings in four areas: the Lorraine workings, the Whim shaft, the Mount Hope No. 1 adit, and the Mount Hope No. 2 adit.

The major workings in the Lorraine area were opened in 1886. In 1890 Thomas Wren drove the Mount Hope No. 2 adit; Wren also sank the Whim shaft. In 1926 the U.S. Smelting, Refining, and Mining Co. drove the Mount Hope No. 1 adit, and in 1928 the property was optioned to the Universal Exploration Co. Universal prospected by churn and diamond drilling and purchased the property in 1930. Additional exploration work was done by a number of lessees until the early 1940's, when Callahan Zinc-Lead Co. obtained a long-term lease and initiated an extensive drilling and development program, including the construction of a power plant and concentrating mill. Exploration in 1943, 1944, and 1945 included a drilling program conducted by the U.S. Bureau of Mines (Matson, 1946). The first concentrates were shipped in 1945, but the mine was shut down in 1947 after a fire destroyed the powerhouse. Production was not reported in the period 1947-57. Total production has amounted to more than $1 million.

The Lorraine workings consist of a main adit (0 level) about 240 feet long and two shafts 90 and 135 feet deep with drifts on the 30-, 50-, 85-, and 130-foot levels, the total workings amounting to 1,769 feet (Matson, 1946, p. 5). The Whim shaft is 90 feet deep. The No. 1 adit is about 800 feet long and has about 3,255 feet of drifts, crosscuts, raises, and winzes. The No. 2 adit is 1,350 feet long and has about 1,745 feet of subdrifts, crosscuts, and raises. The mine workings explore the contact of an alaskite stock with the Paleozoic rocks. The ore bodies are replacement deposits in limestone roof pendants that have been wholly or partly engulfed by the alaskite stock. The principal ore minerals are marmatite, ferruginous sphalerite, galena, pyrrhotite, and chalcopyrite. The principal gangue minerals are calcite and garnet. A composite sample of ore from the No. 1 adit was analyzed by the U.S. Bureau of Mines with the following results (Matson, 1946, p. 6):

Constituent ..	Zn	Cd	Cu	Pb	Fe	S	CaO	MgO	Al_2O_3	Insol.
Percent	13.45	.6	.1	.05	10.6	13.2	12.8	3.6	1.8	50.4

Ounces per ton

Au	trace
Ag	0.96

The principal minerals extracted from the Mt. Hope mine are cadmium-zinc, lead, copper, iron and minor amounts of gold and silver. Actual production figures are available only for the years 1941 to 1947, as reported by the U.S. Bureau of Mines' mineral year books and Roberts, et al (1967) (p. 103):

Year	Gold (oz)	Silver (oz)	Copper (lb)	Lead (lb)	Zinc (lb)	Total Value
1941	...	4	1,000	...	...	$ 121
1944	27	4,377	...	6,526	349,130	50,034
1945	17	16,205	12,682	128,864	2,276,275	286,676
1946	...	...	...	...	...	...
1947	39	43,111	43,993	305,713	7,564,049	998,562
Total	83	63,697	57,675	441,103	10,189,454	1,335,393

An extensive drilling and development program by the Mt. Hope Mining Company and Phillips Petroleum Division of Minerals during 1970-1971, confirmed that substantial copper mineralization occurs at depth and a low grade but continuous molybdenum mineralization also occurs. Additional studies and drilling by EXXON Minerals Company has revealed two deep stocks having concentric alteration zones with substantial molybdenum mineralization areas which overlap one another.

An interesting zonation of minerals occurs in the known ore bodies in the mine area. The drilling program revealed that the zinc, copper and molybdenum mineralization follows a distinctive zonal pattern with the zinc minerals at the top, followed by copper and then molybdenum. This zonation correlates with the known ore bodies and suggests the nature of district-wide zonation, which could prove significant for future exploration and development.

CHAPTER 3.0
IMPACT ANALYSES

3.1 Introduction

The analysis of potential topographic and geologic resource impacts was conducted with an emphasis of two major criteria of effects: (1) extent of topographic variation; and (2) seismic risk as related to earthquake hazard. The direct impacts specific with topographic alteration and the potential for seismic risk are presented herein (Sections 3.3.1 and 3.3.2). As noted in the topographic impact discussion, however, the primary impact of significance associated with the proposed earthen forms of non-mineralized material storage areas, mine pit and tailings pond concerns the degradation of existing visual resources, which is detailed specifically in Technical Report No.8.

An impact analysis associated with geochemical/mineralogic processing was similarly directed from a secondary viewpoint, i.e. an analysis of impact regarding groundwater seepage quality resulting from mineralogic processing end-products, the tailings. As such, the impacts of the mineral processing, intrinsic to the geology of ore extracted, are presented in Technical Report No.4.

Alternatives identified in association with the proposed power line and water line rights-of-way would not impact topography or geology of the area. As such, the discussion which follows would apply equally to either of the alternatives, assuming mining operations proceed. Alternatives regarding tailings pond site selection would significantly affect topography and as such is discussed in this section.

3.2 Assumptions and Analysis Guidelines

The determination of environmental impacts upon the topographic and geologic bases required that certain assumptions be made which would affect conclusions regarding significance and nature of impact (beneficial/detrimental). The general assumptions used in the analyses are presented below.

1. It was assumed that the proposed action and alternatives described briefly in Chapter 1.0 of this Technical Report and in detail in Chapter 2.0 of the EIS and Technical Report No.1 would be implemented as described. Mitigation measures described in the EIS would be in place at time designated and as described. Assumptions 2 through 10 below highlight particularly important aspects of the proposed action and alternatives described, as related to topography and geology.

2. The proposed action would result in topographic alterations in the following areas and in the amount of land acreages shown.

	Temporary
Mine Pit	700 acres
Non-Mineralized Material Storage Areas (2)	2,400 acres
Tailings Pond 4-A	3,460 acres
State Route Relocation	63 acres

The excavation of 120,000 tons of rock per day (30,000 ore tons) would, over the life-of-mine period, result in a pit development with high and low walls of approximately 3,600 and 2,300 feet high. Distance across the pit would be approximately 6,900 feet.

The non-mineralized material storage areas would be developed in a bench-like manner with the overburden material. Bench crest elevations would differ by 330 to 900 feet (100 to 200 meters) at the southern and northern material storage areas, respectively.

The tailings pond dam would crest at an elevation of 6,447 feet, a 397-foot height. Tailings material behind the dam would correspondingly fill to elevation.

State Route 278 relocation would require alignment within an area of severely limiting topography, as proposed. The alignment proposed has not been surveyed, as such exact topographic alterations have not been proposed (see item 6).

Approximately 200 acres of land could be topographically impacted by the proposed development of an employee subdivision. The impacts associated with the subdivision development relative to topography/geology were not evaluated because of the uncertainty of eventual subdivision siting location. Based on the land use reviews (Technical Report No.8) conducted, however, lands suitable for development without topographic alteration (and the costs associated with such) are of sufficient quantity so as to justify preclusion of potential significance to topography/geology.

3. Tailings Pond Alternative 4-B (Diamond Valley) and 4-C (Kobeh Valley) would be constructed so as to have ultimate dam crest elevations of 5,922 and 6,619 feet, respectively. (Dam heights of 78 and 249 feet, respectively). Tailings material behind (or within as at 4-B), the dam(s) would correspondingly fill to elevation.

4. Upon cessation of mining, the mine pit and non-mineralized material storage areas would not be reclaimed, all other mine areas would be reclaimed. The topographic effect of tailings pond development would, however, remain after project cessation.

5. The design of the tailings dam would be approved, prior to construction, by the State of Nevada Division of Water Resources. The dam would be constructed using competent material which would be processed and sized to meet the structural and safety requirements of the dam. The dam was designed to resist earthquake forces (which have a 90 percent likelihood of not being exceeded in a 50-year period) that might be generated by seismic activity at the site.

6. The topographic alterations of highway relocation would be conducted in accordance with Nevada Department of Transportation standards regarding cut and fill requirements, particularly stabilization. Additionally, it was assumed that the proposed realignment best suits topography as presently existing, specifically the maximum utilization of natural topography to allow minimal cut and fill operations.

3.3 Impacts to Area Topography

3.3.1 Proposed Action

Inherent to the proposed action of mining by open-pit methods and the development of non-mineralized material storage and tailings pond areas is a topographic alteration of significance. Neither the mine pit, tailings pond or non-mineralized material storage areas can reasonably or effectively be reclaimed to original approximate contour. Figures 3-1 through 3-4 illustrate, via computer simulated contours, the premine and postmining topography. The proposed action basically involves the transformation and subsequent redistribution of consolidated intact material eventually totalling 650 million cubic yards (21 million cubic yards of non-mineralized material assuming no expansion and 629 million cubic yards of tailings). As illustrated in Figures 3-1 through 3-4, the net effect is the "coring" of Mt. Hope, partial filling of the interior basin hollow with tailings, and the elevational raising of the Mt. Hope ridges.

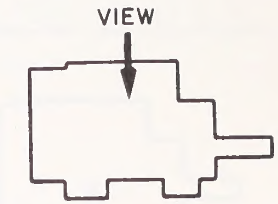
The topographic alterations would be direct significant impacts, both in terms of the topography itself and secondarily such as in the consideration of visual resource degradation (Technical Report No.8).

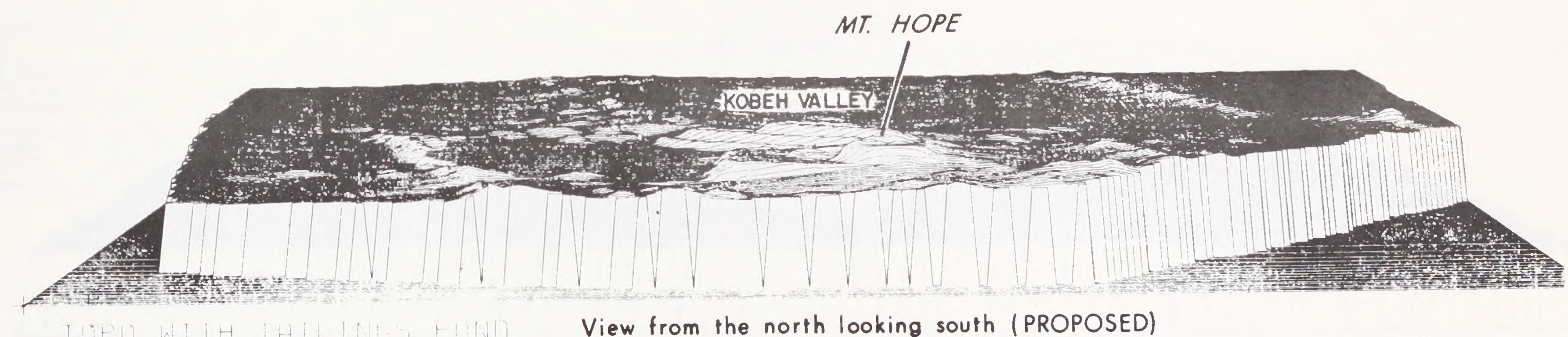
3.3.2 Alternatives

As stated previously, the alternatives of power line and water line routing do not affect topography. No alternative was identified relative to highway relocation.

Tailings pond Alternatives 4-B and 4-C, however, present topographic alterations of generally similar significance as that defined for the proposed action. Alternative 4-B, Diamond Valley, would result in a topographic alteration of lesser elevational variance (dam height 78 feet versus 397 feet at Alternative 4-A) but would represent a topographic feature of sharp contrast to the uniformly low valley floor. Alternative 4-C, Kobeh Valley, would similarly result in a topographic alteration of lesser elevational variance (dam height 249 feet). While not representing the

View from the north looking south (EXISTING)





View from the north looking south (PROPOSED)

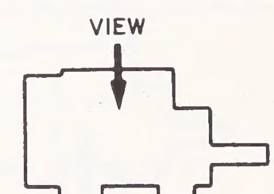


FIG. 3-1
PERSPECTIVE OF MT. HOPE EXISTING TOPOGRAPHY
VS. PROPOSED ACTION TOPOGRAPHY
(Includes Mine Pit, Tailings Pond, Non-Mineralized Storage Areas)

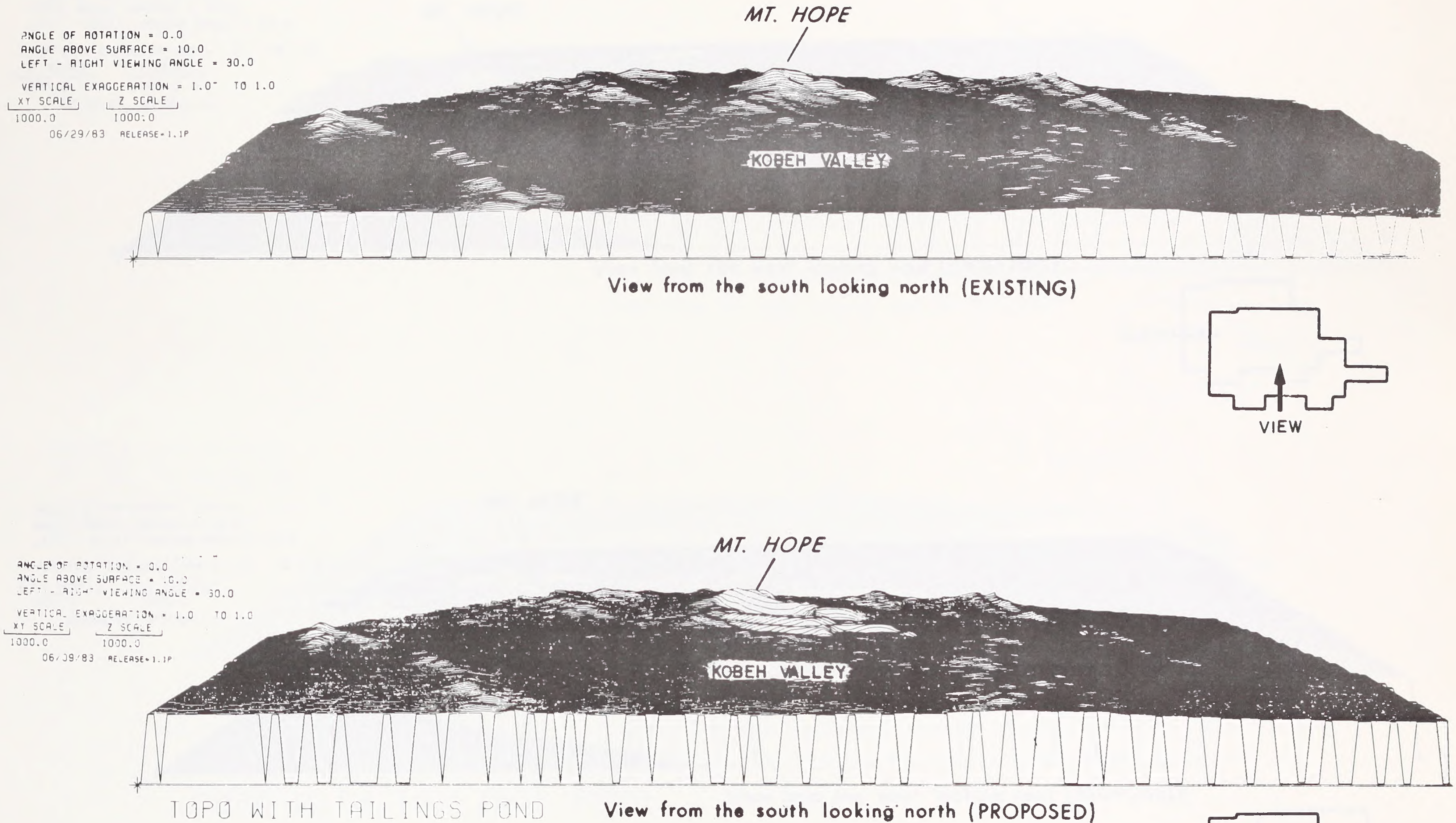
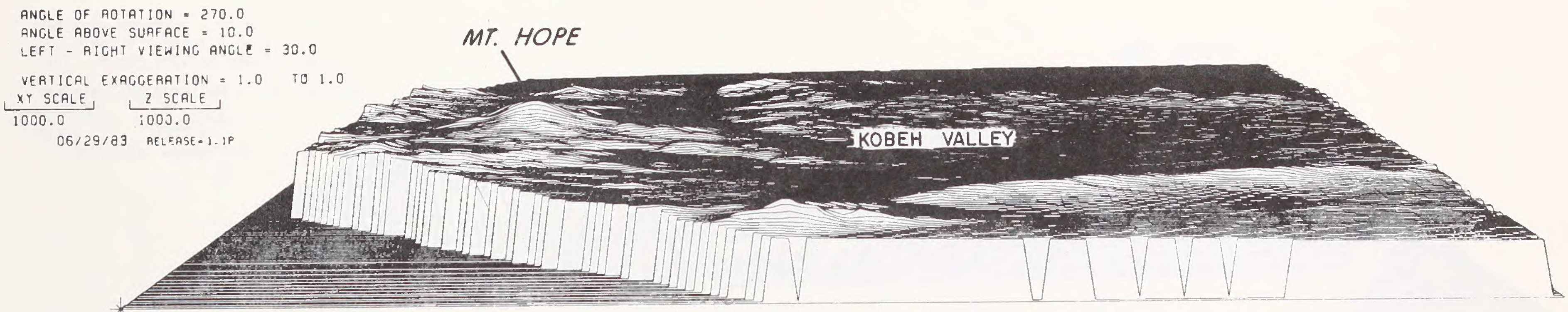
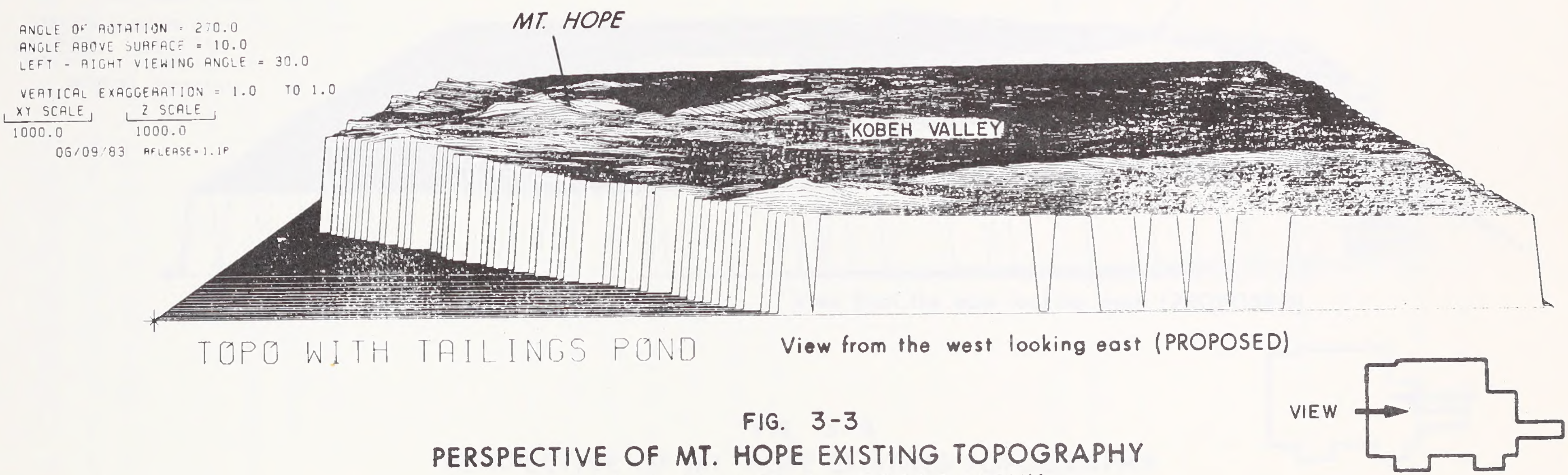


FIG. 3-2
PERSPECTIVE OF MT. HOPE EXISTING TOPOGRAPHY VS. PROPOSED ACTION TOPOGRAPHY
(Includes Mine Pit, Tailings Pond, Non-Mineralized Storage Areas)



View from the west looking east (EXISTING)



View from the west looking east (PROPOSED)

FIG. 3-3

PERSPECTIVE OF MT. HOPE EXISTING TOPOGRAPHY VS. PROPOSED ACTION TOPOGRAPHY

(Includes Mine Pit, Tailings Pond, Non-Mineralized Storage Areas)

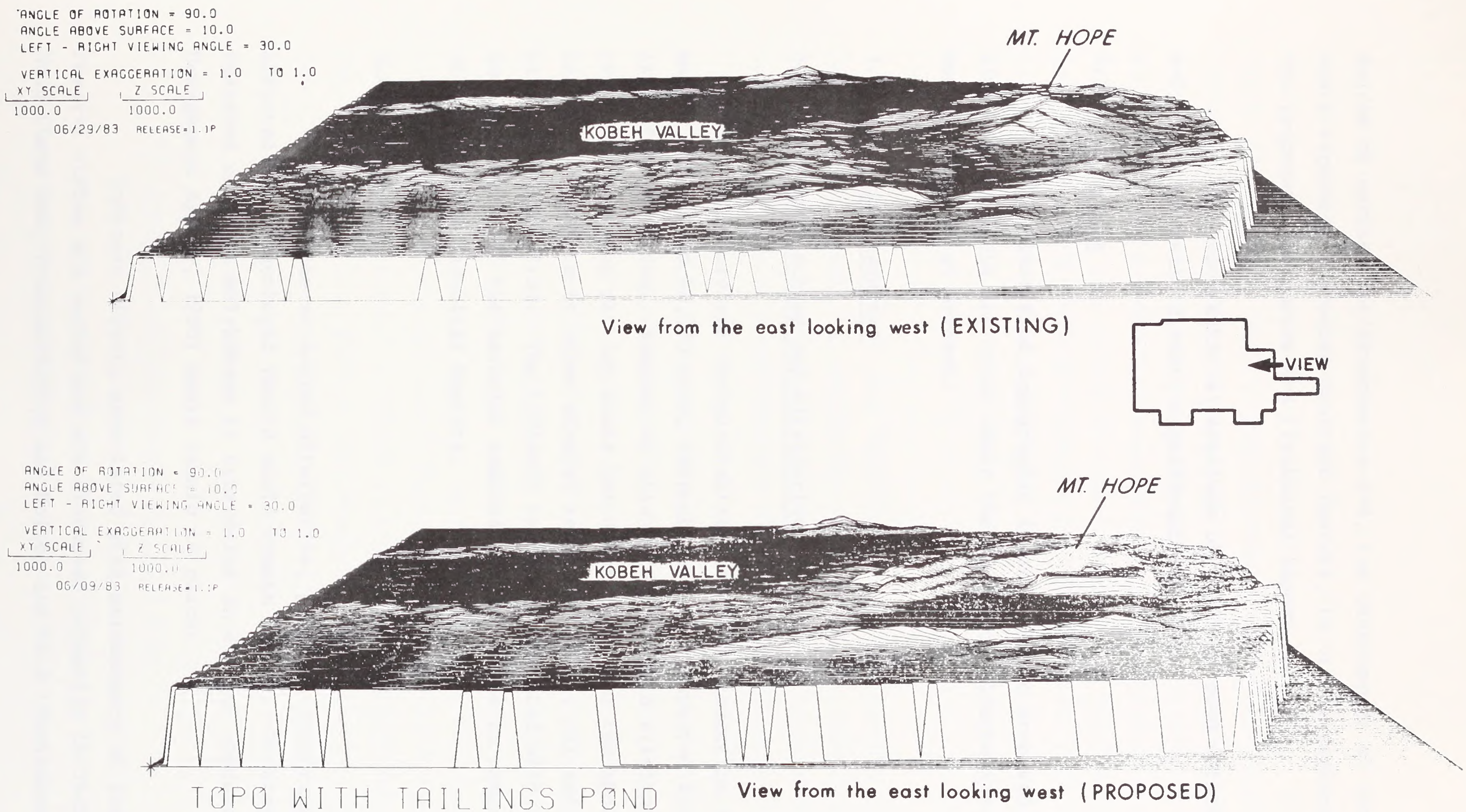


FIG. 3-4

PERSPECTIVE OF MT. HOPE EXISTING TOPOGRAPHY VS. PROPOSED ACTION TOPOGRAPHY

(Includes Mine Pit, Tailings Pond, Non-Mineralized Storage Areas)

degree of variance at Alternative 4-B, the development of Alternative 4-C would represent a greater contrast feature, in visual resource terms, than the proposed Alternative 4-A (Technical Report No.8).

The topographic alterations of tailings pond Alternatives 4-B and 4-C would represent direct, significant impacts.

3.3.3 No Action

The identified topographic impacts of the proposed action and alternatives would not occur under the no action alternative. Topography would remain as at present.

3.4 Geologic Resources

3.4.1 Proposed Action and Alternatives

Daily ore and non-mineralized material production rates of approximately 30,000 and 90,000 tons, respectively, are expected during the 50-year life-of-mine action. Removal of this material would eliminate the geologic record in the mine pit but would not directly affect the geology of adjacent lands. No impacts to other mineral resources (e.g., oil and gas, geothermal) have been identified. The indirect impacts associated with the processing and relocation of the material removed are discussed in numerous sections of the EIS and Technical Reports.

3.4.2 No Action

Under the no action alternative, geologic resources would not be affected as the geologic record would remain intact. Strategic mineral reserves of which molybdenum is considered an element (Federal Emergency Management Agency, 1980) would remain in place.

Indirect effects associated with maintenance of the in-ground reserve status are varied and are discussed primarily in Technical Report No.8 (Land Use, Transportation and Noise) and No.9 (Socioeconomics). It

was noted in the analysis of geologic impacts however, that ore extraction and processing would require a development lead time in excess of four years (without regulatory permit approval time considerations). While the United States is normally a net exporter of molybdenum ore products, financial, industrial and geopolitical conditions have been recognized in its FEMA listing which imply relative importance of mineral stockpile accessability. Relative to the Mt. Hope ore availability, such stockpile accessibility would entail the time period discussed above. The significance of such delay could not be readily evaluated for EIS purposes, primarily due to fluctuations and uncertain status of other molybdenum ore body developments.

3.5 Seismic Risk

Chapter 2.0 of this Technical Report details the seismicity of the Mt. Hope region. As noted, the proposed action and alternatives would be located in a Zone 2 seismic risk area where earthquake activity occurrence could be expected to cause moderate damage (NOAA, 1973).

During preliminary project engineering, earthquake hazard analyses were conducted to evaluate seismic risk potentials associated with mine/non-mineralized storage areas and tailings pond features. Analysis of seismic risk relative to tailings pond siting involved design considerations necessary to reduce or eliminate impacts resulting from tailings embankment damage in the event of a major earthquake. The analyses conducted were reported by Call & Nicholas, Inc. with evaluation by Dr. Charles E. Glass of the University of Arizona (Call, Nicholas and West, 1982, Seismic Appendix). The following provides a detailed abstract of the analytical findings regarding preliminary seismic risk evaluations for the Mt. Hope site in general and the proposed and alternate tailings ponds Alternatives 4-A (proposed action, rank No. 1 in site selection) and 4-B (alternative, rank No. 2 in site selection).

3.5.1 Earthquake Hazard Analysis - Mt. Hope Site

The earthquake hazard analysis was based on the theory of extremes developed by Gumbel (1958). The theory of extremes provides a convenient

method for obtaining estimates of earthquake hazard. The technique treats earthquake occurrence as a stochastic process F(x,t) where x is the variable of interest for design. For example, x may correspond to earthquake magnitudes recorded within a specific region, or to earthquake accelerations or intensity values at a particular site. Often the engineering design depends less on an accurate knowledge of F(x,t) than on the largest value that x can assume within a given design period. If the entire earthquake catalogue [F(x,t)] is accurately known, then the maximum values of x are likewise known. The complete data needed for precise definition of F(x,t), however, are generally unavailable for most regions. Because the larger events are usually recorded, even in regions having poor instrumentation, the extreme value technique, which uses these maximum values, provides a useful tool for such stochastic processes.

For analytical purposes, the time scale is first divided into yearly intervals. Only the extreme value y, which the variable x reaches within each interval, is considered in the analysis. The extreme value y forms a regular point process within the original process F(x,t). Gumbel found only four mathematically distinct distributions of y. His "Type 1" distribution takes the form:

$$G(y) = \exp(-\alpha e^{-\beta y}) \qquad (1)$$

where α and β are found from a least squares fit.

When the parameters α and β have been determined, the probabilities of occurrence of an earthquake with a magnitude greater than the extreme value y are calculated from:

$$P(y) = 1 - \exp(-\alpha D e^{-\beta y}) \qquad (2)$$

where D is the number of years over which the probability is to be assessed.

The intensity distribution of ground motion at the site was estimated by applying representative attenuation relationships to each individual earthquake in the earthquake catalogue and performing a Gumbel

analysis on the resulting site intensity distribution. The attenuation relationships used in the study were developed by Esteva and Villaverde (1974) and correspond to attenuation characteristics common to the western United States.

Results of the Gumbel analysis are illustrated in Figures 3-5 and 3-6. Figure 3-5 illustrates the number of earthquakes causing a given ground acceleration at the site in a specified period of years. For statistical example, one earthquake producing site acceleration of 0.04g would be expected in the next 50 year period. Figure 3-6 illustrates the earthquake acceleration hazard which is defined as the probability of equalling or exceeding a given level of ground acceleration within a specified period of years. For example, the probability of experiencing a ground acceleration at the Mt. Hope site of 0.06g over the next 50 years is 0.14.

The analysis indicates that only the 1915 Pleasant Valley earthquake (Chapter 2.0) produced a ground acceleration at the Mt. Hope site exceeding nine percent of g. It is unlikely that future earthquakes would produce accelerations at the site higher than nine percent of g, given the tectonic conditions in the Mt. Hope area. If higher accelerations were encountered, they would likely be due to nearby earthquakes having small magnitudes, short durations, and high frequencies (Glass, in Call & Nicholas, Inc., 1982).

Figure 3-6 also illustrates that there is approximately a 50 percent probability that a ground motion exceeding 0.02g will occur at the site within the next 5 years. Figure 3-5 illustrates that an earthquake with an acceleration of at least 0.02g would be expected to occur every 7.2 years. Figure 3-7 depicts earthquake hazard in terms of Richter scale magnitude. Seismic events are commonly considered "major" if their magnitude exceeds 7.0. A 0.09 g would be similar to that experienced at Mt. Hope during the 1915 Pleasant Valley earthquake having a magnitude (M) of 7.6.

3.5.2 Pit Slope Stability

In its seismic report summary, Call & Nicholas, Inc. concluded that the effects of a 2 percent g load would be minimal, with only minor

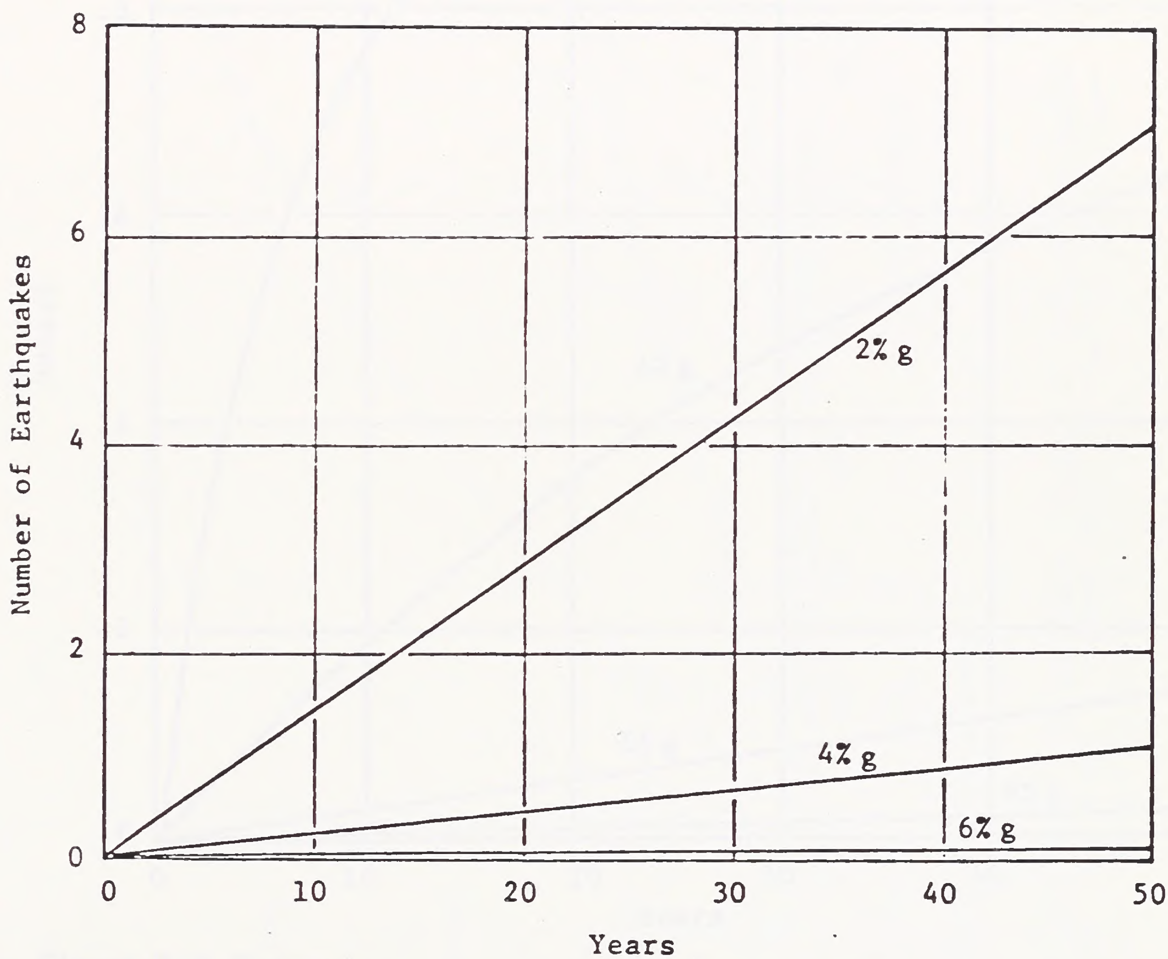


Figure 3-5 Number of times site ground motion is expected to exceed a specified maximum acceleration in a given period of years.

Source: Call and Nicholas, Inc., 1982.

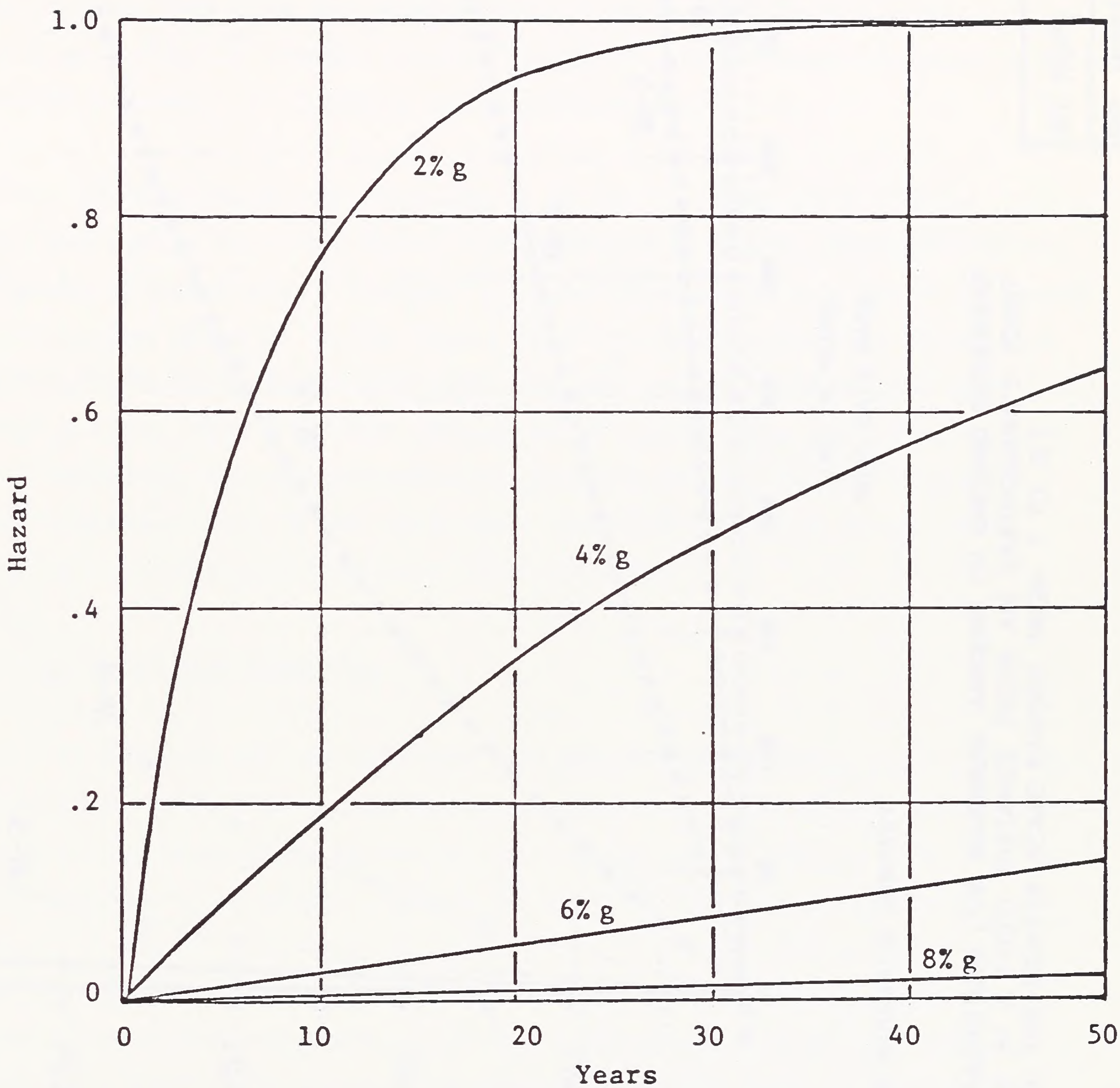
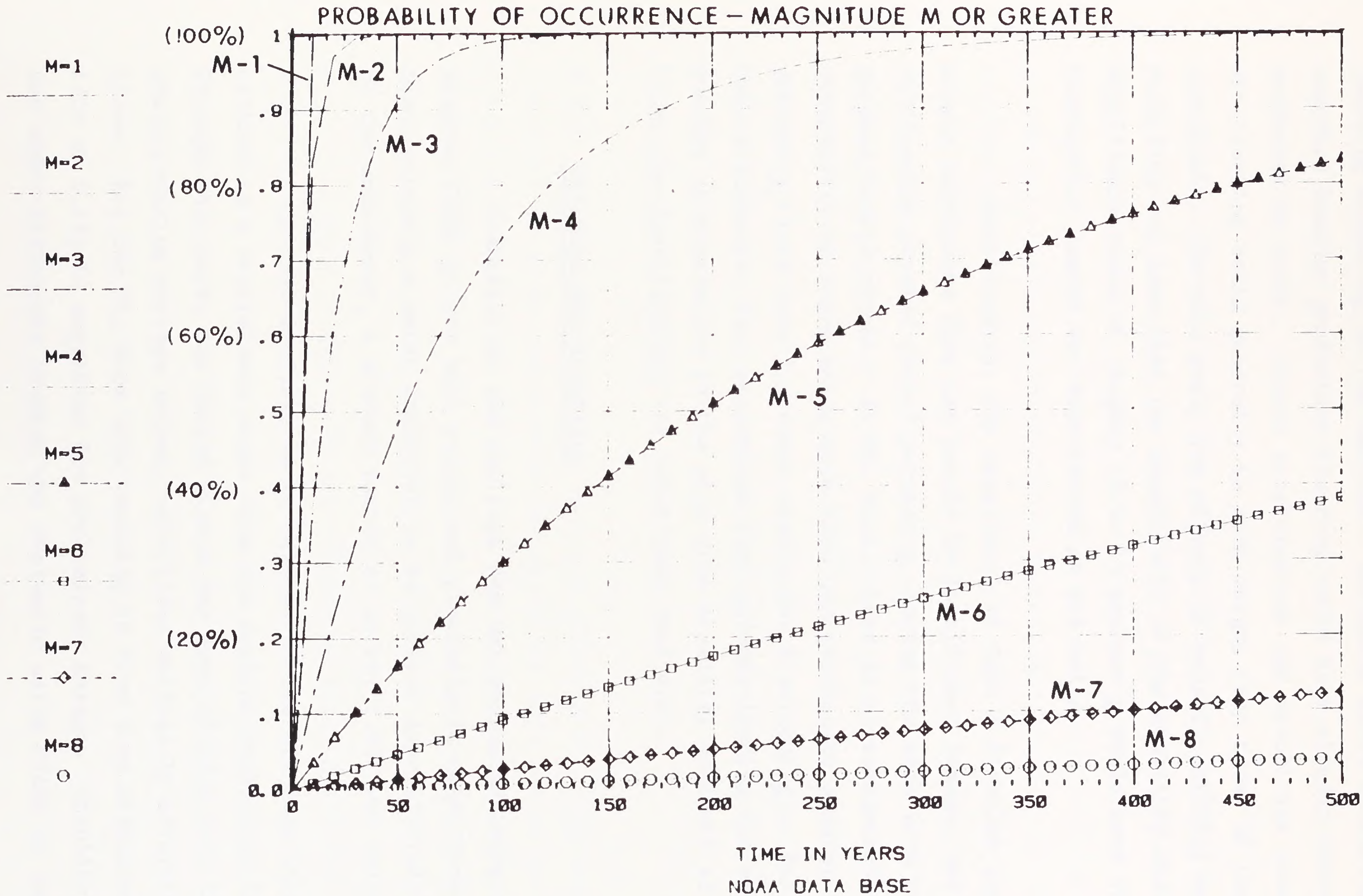


Figure 3-6 Earthquake Acceleration Hazard. (The probability that a specified ground acceleration will be exceeded at the site in a given period of time).

Source: Call and Nicholas, Inc., 1982.



SOURCE: EXXON MINERALS COMPANY

M— RICHTER MAGNITUDE (THE MAXIMUM AMOUNT OF GROUND MOVEMENT MEASURED AT A FIXED DISTANCE FROM AN EARTHQUAKE'S POINT OF ORIGIN; THE RICHTER SCALE RANGES FROM 1 TO 10)

MT. HOPE MOLYBDENUM PROJECT

MT. HOPE EARTHQUAKE HAZARD DATA BASE WITHIN 95 MILE RADIUS OF SITE

U.S. Department of the Interior
Bureau of Land Management

FIGURE 3-7

raveling occurring on the benches. Extensive bench backbreak would not be expected because production blasting would have already caused most potential backbreak to occur. Ground accelerations and velocities induced by routine pit blasting would generally be much larger than those of the design earthquake. In this area, the effects of seismic activity on overall slope stability are less than the sensitivity of the stability analysis. Significant risks of roughly 10 to 15 percent g would have to occur before substantial damage was experienced at pit walls.

Additionally, the experience of Call & Nicholas indicates that a single earthquake does not result in significant damage, but that several earthquakes greater than 5 percent g, during the mine life would represent greater hazard threat. At Mt. Hope, there is approximately a 30 percent probability of there being more than one earthquake greater than only a 5 percent g (less than 2 percent chance for 8 percent g). For this reason, Call & Nicholas, Inc. determined that seismic loading did not require further consideration in the mine area stability analysis at Mt. Hope (i.e., no justification for worst-case analyses).

3.5.3 Tailings Dam Stability

Stability of the tailings dam was evaluated using the computer program STABL 1/ for both static and pseudostatic conditions. For the static case, assuming a water condition to be present approximately half the depth of the embankment, a minimum factor of safety 1.894 was calculated.

Seismic activity as it relates to the Mt. Hope site can be characterized in a preliminary sense from the Applied Technology Conference, 1978. Through this work, the United States has been divided into four zones characterizing average seismic activities defined by effective peak accelerations. For the Mt. Hope site residing in Zone 2 an effective peak acceleration of 0.1lg is suggested for preliminary design. Stability of the trailings dam under earthquake loading was evaluated using STABL by imposing a 0.1g

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1/ Computerized Slope Stability Analysis of Indiana Highways, Final Report, Joint Highway Research Project No. C-36-36L, Purdue University, Dec. 1977.

and a 0.15g pseudostatic horizontal acceleration on the structure. The results of these analyses produced minimum factors of safety of 1.42 and 1.26, respectively.

The results of the analyses utilizing the 0.15g pseudostatic horizontal acceleration are presented in Figures 3.8 and 3.9. Figure 3.8 shows the embankment geometry and a summary of all sheer surfaces evaluated during the analysis. Figure 3.9 shows the ten most critical shear surfaces generated and the minium factor of safety and critical slip surface determined.

In summary, the conceptual embankment design for the tailings facility as proposed by Wahler Associates using the centerline method of construction and a three horizontal to one vertical downstream slope ratios should be adequate to provide a satisfactory level of stability under static, as well as dynamic or earthquake loading conditions.

3.6 Mineral Processing

Minerals processing data was provided by EXXON in the form of elemental tailings composition estimates for both the solid and liquid fractions. Tables 3-1 and 3-2 list the expected compositions of solid and aqueous fractions of the tailings that would be generated at the proposed mineral processing facility at Mt. Hope.

Based on review of the laboratory testing results and on-line experience indicated at the operation of Duval Sierrita Company's (Duval Corporation) copper-molybdenum mining installation near Tucson, Arizona, the data presented in Tables 3-1 and 3-2 appear to appropriate for subsequent analysis of hydrologic impact. The impacts associated with tailings materials generation are reviewed in Technical Report No.4.

3.7 Mining Industry Impacts

Analyses of mining industry effects resulting from implementation of the proposed action and alternatives (similar in cause of effect,

Table 3-1 Estimated Composition of Solid Fraction of Tailings

Element Determined	Weight % as Mineral	
Cu	0.04	($CuFeS_2$)
Fe	0.39	(FeS_2)
Fe	1.03	(Fe_2O_3)
Zn	0.06	(ZnS)
Pb	0.01	(PbS)
As	0.02	($FeAsS$)
Cd	not detected	
Bi	not detected	
Mn	0.06	(Mn_2O_3)
Na	0.46	(Na_2O)
K	6.52	(K_2O)
Si	79.10	(SiO_2)
Al	10.16	(Al_2O_3)
Sn	not detected	
W	0.04	($(FeMn)WO_4$)
Ba	0.05	($BaSO_4$)
P	0.04	(P_2O_5)
Total	98.45	

SOURCE: EXXON Minerals Company

Table 3-2 Estimated Composition of Aqueous Fraction of Tailings

Element	Concentration After Eight Cycles (ppm)	Estimated Equilibrium Concentration (ppm)1/
Ag	0.01	-
Al	0.16	-
As	<0.063	-
B	0.012	-
Ba	0.058	-
Be	**	-
Ca	40.0	-
Cd	0.0091	-
Co	**	-
Cr	0.0068	-
Cu	0.0041	<1.0
Fe	0.21	1.0
K	58.1	-
Li	0.058	-
Mg	11.04	-
Mn	0.278	5.0
Mo	1.083	-
Na	48.54	-
Ni	0.0068	-
P	1.611	-
Pb	**	-
Pt	**	-
Sb	**	-
Se	**	-
Si	3.58	-
Sn	1.26	-
Sr	0.08	-
Ti	**	-
Tl	**	-
U	**	-
V	**	-
W	**	-
Zn	0.035	<1.0
Cn-	1.858	1.0
Total Sulfur	94.5	-
SO_4=	86.9	500
CO_3=	0.65	-
HCO_3-	159.7	-
TOC	17.24	-
TDS	621.0	1000

** Below detectable limit.

1/ First column represents laboratory results of metallurgical testing using Kobeh Valley water recycled eight times. For most constituents these estimates approximate equilibrium concentrations. Those constituents which may further build up are shown in the second column with the extent of build-up having been estimated based on operating experiences at other similar molybdenum processing facilities.

SOURCE: EXXON Minerals Company

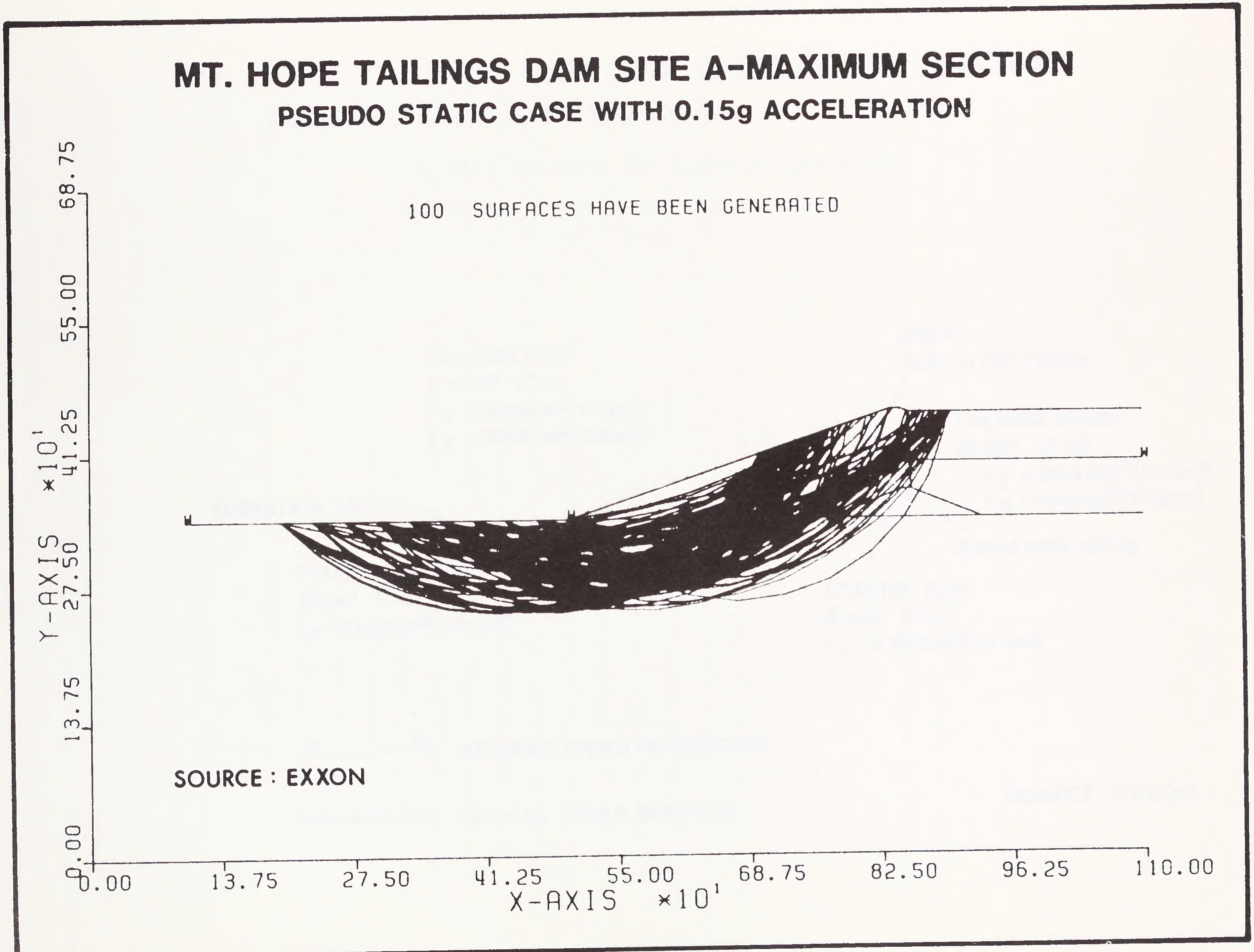
MT. HOPE TAILINGS DAM SITE A-MAXIMUM SECTION
PSEUDO STATIC CASE WITH 0.15g ACCELERATION
100 SURFACES HAVE BEEN GENERATED
Y-AXIS ×10[1]
0.00
13.75
27.50
41.25
55.00
68.75
X-AXIS ×10[1]
0.00
13.75
27.50
41.25
55.00
68.75
82.50
96.25
110.00
SOURCE : EXXON

FIGURE 3-8

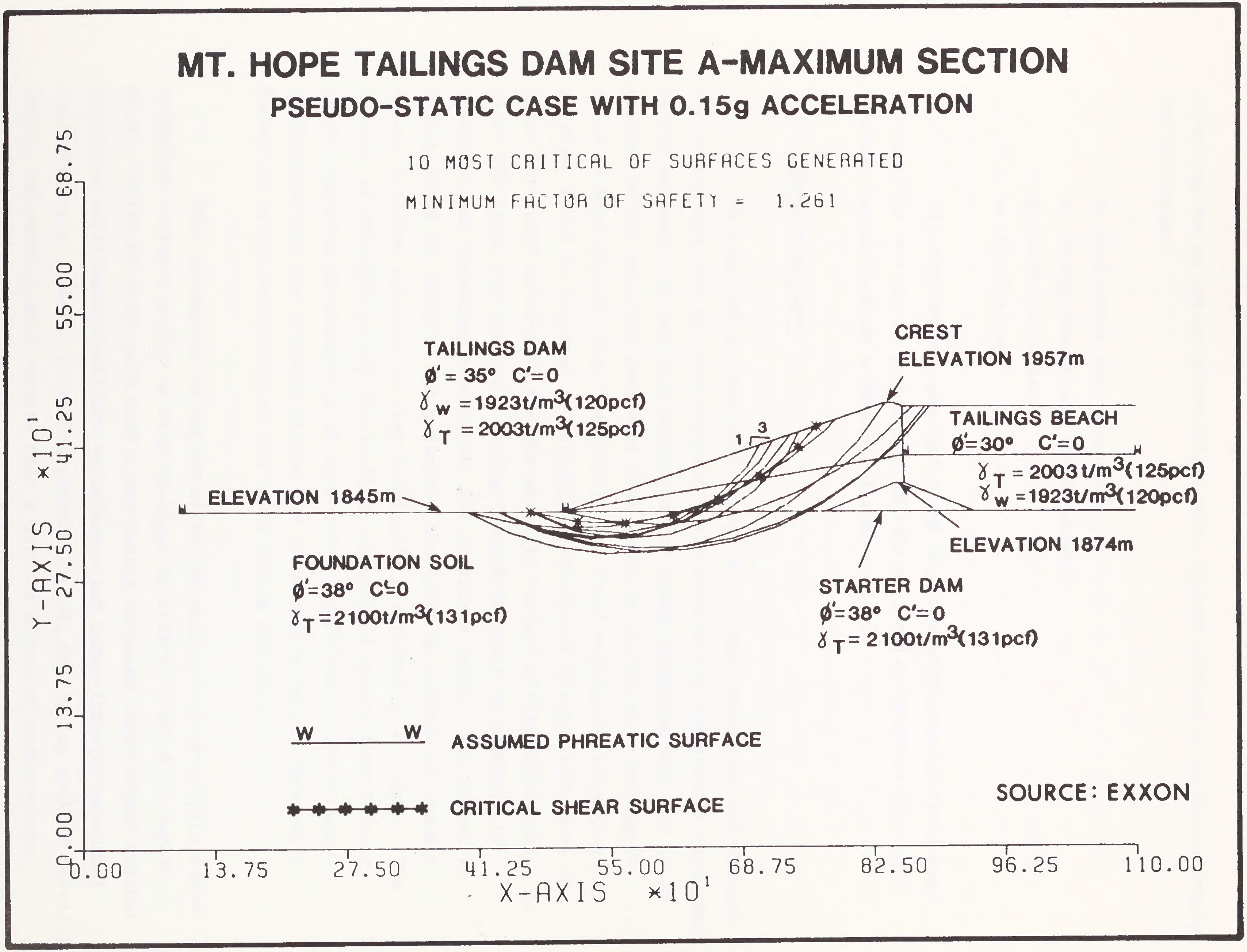
MT. HOPE TAILINGS DAM SITE A-MAXIMUM SECTION
PSEUDO-STATIC CASE WITH 0.15g ACCELERATION
10 MOST CRITICAL OF SURFACES GENERATED
MINIMUM FACTOR OF SAFETY = 1.261
TAILINGS DAM
Ø' = 35° C'=0
γ w =1923t/m3(120pcf)
γ T =2003t/m3(125pcf)
CREST
ELEVATION 1957m
TAILINGS BEACH
Ø'=30° C'=0
γ T = 2003 t/m3(125pcf)
γ w =1923t/m3(120pcf)
ELEVATION 1845m
ELEVATION 1874m
FOUNDATION SOIL
Ø'=38° C'=0
γ T =2100t/m3(131pcf)
STARTER DAM
Ø'=38° C'=0
γ T = 2100t/m3(131pcf)
1 3
W W
ASSUMED PHREATIC SURFACE
CRITICAL SHEAR SURFACE
SOURCE: EXXON
Y-AXIS ×10¹
X-AXIS ×10¹
0.00
13.75
27.50
41.25
55.00
68.75
82.50
96.25
110.00

FIGURE 3-9

excepting the no action alternative) were limited primarily to the following topical areas:

- Employment Base Resources
- Fiscal Resources (Socioeconomic)
- Land Use Criteria
- Air Quality

Inter-producer competition and Mt. Hope production effects were not analyzed nor was it deemed appropriate or legally mandated that such analyses be included as a NEPA compliance measure.

3.7.1 Employment Base

As detailed in Technical Report No.9 (Socioeconomics) and Chapter 2.0 of the EIS, the Mt. Hope Project would require the operational employment of 640 persons. It has been estimated for impact purposes that 525 or 82 percent of the required personnel base would be non-local (residing 90 miles or more distant from the site). The local workforce, totalling 115 persons, would be required in variable professional disciplines, some of which have been assumed to include directly related mining experience. As such, the local and non-local mining industries would be expected to experience an increased competition for workforce labor. The extent of impact would be variable and primarily dependent on individual company salary policies relative to that eventually estalished at Mt. Hope. The absence of detailed salary information, considered proprietary in most cases, required an assumption of worst-case conditions in which, upon implementation, the proposed action and alternatives would represent a factor of salary escalation in the local mining industry.

This assumption is supported by the increase in per capita rates evidenced during a period of mine openings in 1980-81 (Technical Report No.9). While in large part such a per capita increase could simply reflect increased employment/population percentages and inter-industry personnel transfers (e.g., retail to mining administration, etc.), the lack of detailed salary information does require that a certain degree of market-place

competition (e.g., salary, benefits, etc.) relative to utilizing the limited workforce available be assumed. To an unidentified extent, the same salary escalation could be realized at non-local operations (e.g., Carlin area) as mine operators strived to prevent out-migration of workforce personnel.

Determination of end result impacts to the local and non-local mining industries of any salary escalation would require speculation concerning the in-place personnel workforce and the condition of the mining industries involved. While at present (1983), the employment base of mining experienced personnel may be under utilized due to operational slowdowns brought about by recession economics and mineral demand, the availability and utilization of the mining-based personnel resources is historically fluctuational. Thus, net impact would be dependent on timing of personnel demand, extent of salary influence and national/state economics. On a worst-case basis, it would appear appropriate to conclude that small and/or financially limited mining ventures may be adversely impacted, choosing either to maintain salary status quo and face potential loss of all or part of its workforce base or choose to lower profit margin but maintain operations by establishing a responsive salary policy.

Technical Report No.9 provides further detailed information concerning socioeconomic impact, including net employment impacts.

3.7.2 Fiscal Resources

The fiscal resources of Eureka County, Eureka County School District and the Town of Eureka are defined significantly on the basis of the county's mining industry prosperity. As detailed in Technical Report No.9, mining industry proceeds account for up to 72 percent or more (1982-1983 mine property tax valuation equal to $49.95 million of county total equal to $68.72 million) of a major source of county finance base. Combined with the 55 percent of county employment share (1981), the mining industry of Eureka County directly influences population lifestyles via the general availability of community resources financed by County and School Districts.

The fiscal resources impact that the cumulative mining operations provide correspondingly relate to a county dependency of certain extent. While ranching and farming, particularly in Diamond Valley exert and enjoy an apparently strong degree of economic, social and political influence, much of the responsibility for such influence additionally is shared by the county mining industry. As detailed in Technical Report No.9, implementation of the Mt. Hope proposed action and/or alternatives would in effect nearly double the Eureka County and School District available budgetary resources, thereby increasing the percentage of proceeds committed by nearly 50 percent or more of the existing level.

Within the mining industry community of Eureka County, it has been assumed that implementation of the proposed action and/or alternatives would result in a dilution for individual companies of both the fiscal resource input benefits and detriments (e.g., economic, social, political influence/negative employment responsibility). The dilution of such would be offset by the assumption of those benefits/detriments by the Mt. Hope operator EXXON and the overall increase experienced by the mining industry as a whole entity. Correspondingly, other sector influence would be diminished in terms of economic influence (revenues). The extent to which such diminishment would effect political, social or economic (expenditures decision-making, e.g., County budget planning) responsibilities is not quantifiable (See Technical Report No.9, Lifestyles and Attitudes).

3.7.3 Land Use Criteria and Air Quality

Dedication of the lands within the proposed Mt. Hope acquisition boundary area was not determined to pose land use conflicts within the County or State. Nevada State statutes (NRS 37.010), in recognition of mining value, the right of emminent domain to be exercised in behalf of several public uses, one of which was defined as being mining and related activities and of "... paramount interest" to the state. Additionally, Eureka County planning guidelines (Technical Report No.8) outline land use development desires which include mining and associated support infrastructures. While implementation of the proposed action and/or alternatives would be expected to promote the establishment of County land

use ordinances (either legally established or as policy statements) for such planning or development issues as Eureka Town Historic District protection (remining population housing demands, Technical Report No.9), the potential for such land use development restrictions to adversely affect the county's mining industry individually or as a whole was not identified.

The impacts of the proposed action and/or alternatives associated with air quality are detailed in Technical Report No.3. In summary, the quantitative analysis of air quality effects indicated that the implementation of the proposed action and/or alternatives, particularly the operation of the proposed mineral processing plant complex, would not result in atmospheric emissions in excess of federal National Ambient Air Quality Standards (NAAQS) or state air quality standards. Implementation of the proposed action/alternatives would result in a consumption of air quality "increments". The establishment of air quality increment levels (Clean Air Act of 1970 and Preventions of Significant Detrioration (PSD) regulations) was designed to preclude significant degradation within a certain geographic area of activity. Increment consumption generally is assigned on a first-come basis, each industry consumption reducing correspondingly the amount of increment remaining for other future industry use. (Technical Report No.3 details the specific requirements related to air quality regulations).

The proposed action and alternatives would occur within a designated Class II air quality area (Class I being pristine, Class III being worst-case; the United States being mostly composed of Class II areas). The allowable increase (increment) in ground-level particulate emission matter is 19 micrograms per cubic meter. As detailed in Technical Report No.3, the proposed action and alternatives would, as determined by computer air quality modelling, increase existing baseline concentrations within the project area by as much as 19 micrograms, the maximum allowable increment (worst-case analysis). As such, the implementation of the proposed action/alternatives would effectively result (via PSD permitting) in the affected air quality influence zone being protected from additional emissions being emitted (or settling) in the area. Subsequently, should another industry entity desire to locate in close proximity to the Mt. Hope project, it

would first be required to demonstrate that any of its proposed emissions would not, by atmospheric dispersion, increase the ground-level concentrations of particulate matter within the Mt. Hope "protected" or "increment-limited zone" in a manner that would exceed the established 19 increment total. The requirement to demonstrate lack of effect would apply to any major source undergoing PSD review. Failure to demonstrate maintenance of air quality would result in a regulatory prohibition of new facility development, both in consideration of the desire to maintain satisfactory air quality levels and the Mt. Hope project's prior establishment of increments consumed.

The net impact upon area industry, including mining, of implementing the proposed action/alternative relative to air quality and increment consumption was detrmined not to be significant. At present, no known plans exist for development within the vicinity of Mt. Hope which would pose a potential conflict. While the potential for other industry influence would in part depend the extent of which their respective emissions would dispersed (e.g., one mile, ten miles, etc.), the area influenced by the Mt. Hope project would be contained within the land acquisition boundary areas. A relatively limited area of increment limited air quality would thus exist and would represent, in most cases, a low conflict potential with all but immediately adjacent industry land developers.

CHAPTER 4.0

LIST OF REVIEWERS AND PREPARERS

4.1 Reviewers: Bureau of Land Management

TERESA McPHARLAND, Area Geologist

B.A. Geology, Stephens College, MO.

Experience includes four years experience with Bureau of Land Management; coordinator, writer-editor; geology review.

4.2 Consultants

ROBERT C. WYATT, Project Manager

B.S. in Biology, University of Miami
Post Graduate Study, Biology, University of Miami

Mt. Hope Project: Responsible for coordination of environmental discipline impact analyses (except cultural resources) and direction of the third party EIS scientific team; technical and regulatory (NEPA) oversight and management of EIS documentation; and liaison and coordination with the Bureau of Land Management (BLM) and EXXON.

Experience includes management and technical analyses of environmental impact studies involving surface and underground mines, nuclear and coal-fire electrical generating plants, petrochemical and mineral process facilities, and hazardous waste/nuclear disposal site regulatory analysis. Professional experience involving activity in 23 states, Mexico and Puerto Rico has included the technical critique and environmental discipline analysis of hydrology, air quality, chemical and mine engineering, terrestrial and aquatic biology, socioeconomics, land use, pollutant toxicity and regulatory compliance.

RANDALL K. BUSH, Geologist/Data Analyst

B.S. in Geology, University of Houston

Mt. Hope Project: Assisted in the preparation and data abstraction required for EIS technical reporting. Coordinated EIS documentation relevant to mapping and quality assurance.

Professional experience includes technical writing and regulatory compliance documentation for numerous coal and mineral mines; technical critique of topographic and geologic data and support documentation; and land use analysis (physical environmental factors relevant to engineering planning).

MAXWELL K. BOTZ, Senior Hydrologist

B.S. in Geological Engineering, University of Nevada
M.S. in Geological Engineering, University of California, Berkeley
Ph.D in Hydrology, University of Arizona (dissertation not completed)
Professional Engineer, States of Colorado, Wyoming, Utah

Mt. Hope Project: Responsible as senior scientist for design and supervision of geohydrologic analyses, impact assessments and technical report preparation pertinent to EIS documentation.

Professional experience in excess of twenty years includes project direction for major mining, reclamation and water resources investigations. Emphasizing hard rock and coal mining, experience has included engineering design and construction of a hazardous waste site, development of water surplus, mineral processing treatment research, and groundwater pollution investigations. Employment history has included responsibility as Head of Technical Investigation Section, Water Quality Bureau, Montana Department of Health and Environmental Sciences.

WILLIAM M. O'BRIEN, JR., Visual Analyst

B.S. in Landscape Architecture, Pennsylvania State University
Post-Graduate Studies in Civil Mine Engineering, West Virginia University

Mt. Hope Project: Responsible for visual response evaluation and impact assessment. Prepared technical report and impact section discussion for EIS documentation.

Professional experience includes review and evaluation of mining and reclamation plans, development of mitigative programs, project engineering and plans design. Has assisted in management and preparation of numerous environmental impact statements and EIS's analysis of overall environmental impacts, recreational, planning, esthetics and inventory of natural systems.

Experience has emphasized energy development projects, particularly mine operations, throughout the United States.

4.3 EXXON Minerals Company

WALTER R. DAVIES, Minerals Processing Engineering

Higher National Certificate (Chemical Engineering),
Birkenhead Technical College, U.K.

Mt. Hope Project: Responsible for processing engineering development of molybdenite process facilities.

Experience includes process engineering design and project engineering of major copper and uranium processing facilities and the supervision of primary copper production facilities. For several years managed laboratory and centralized pilot plant facilities for large, integrated, primary metals producer.

EVAN J. ENGLUND, Mining Geology Division

B.S. in Geology, University of Wisconsin
M.S. in Geology, University of Vermont
Ph.D. in Geology, Dartmouth College

Mt. Hope Project: Assisted in preparation of computerized displays of topography.

Experience includes computer applications in geology, resource evaluation, and open pit design.

MOISES J. GARCIA, Engineering Advisor

B.S. Mining Engineering, New Mexico Institute of Mining and Technology.

Mt. Hope Project: Project core team member responsible for coordinating feasibility work in mine design, hydrology, topographic mapping, and bulk sampling.

Experience includes twenty four years in designing, operating, and managing open pit mines. Several years in reclaiming open pit mine areas.

F.P. SCHWARZ, Staff Geologist

B.S. Geologic Engineering, Colorado School of Mines
Ph.D. Geologic Engineering, Colorado School of Mines

Mt. Hope Project: Responsible for field supervision of mining geology activities and preparation of geology narrative.

Experience includes sixteen years in exploration and project evaluation of geology on numerous properties in the western United States and Alaska containing base and specialty metals.

JOHN F. WALLACE, Mine Engineering Division

B.S. Civil Engineering, S.U.N.Y. at Buffalo
MSCE Geotechnical Engineering, West Virginia University

Mt. Hope Project: Responsible for direction of tailings site selection and conceptual site development studies, seismic hazard assessments.

Experience includes execution and management of tailings facility planning and site development studies; geotechnical evaluations for numerous residential, commercial and industrial facilities; resident engineering for several large earthwork construction projects; and specialty consulting.

KAY KAY WONG, Communication and Computer Science Department

B.S. Physics, Seattle University
M.A. Physics, Columbia University

Mt. Hope Project: Responsible for computer graphics in three-dimensional visual display of mining area. Perform finite element analysis in rock mechanics and hydrology.

Experience includes developing a graphics system for satellite data at NASA.

4.4 Whaler Associates

FORREST W. GIFFORD, Manager Mine/Mill Waste Disposal

B.S. in Civil Engineering, Kansas University
Registered Civil Engineer - California

Mt. Hope Project: Responsible for coordination and direction of the tailings site selection and conceptual design development study.

Mr. Gifford is in charge of engineering services and mill/mine waste disposal. These services have included investigations and design of new disposal facilities for uranium, silver, copper, and phosphate tailings facility and have involved various types of both earthfill and tailings embankments. He also has extensive experience in foundation and engineering analysis of existing mill waste embankments and tailings ponds.

ANTONIO S. BUANGAN, Manager Engineering Geology

B.S. in Mining Engineering, Mapua Institute of Technology, Phillipines
Post Graduate Study: Geology, Stanford University
Registered Geologist and Certified Engineering Geologist - California

Mt. Hope Project: Responsible for the direction of all geologic activities associated with the tailings site selection and conceptual designs study.

Professional experience includes conducting engineering and geologic studies to determine foundation conditions, availability of construction materials, seismicity and groundwater conditions for numerous civil engineering projects, including dams, tailings dams, reservoirs, pipelines, roads, and various types of buildings and land development. Broad experience in evaluating and development mitigation measures for geologic hazards such as landslides and faulting related to hillside and highway projects, schools, and hospital sites.

DENNIS BURANEK, Principal Engineer

B.S. in Civil Engineering, San Jose State
M.S. in Civil Engineering, San Jose State
Registered Civil Engineer - California

Mt. Hope Project: Responsible as the principal engineer in evaluating engineering characteristics in relation to site development for tailings site selection, as well as engineer responsible for developing the recommended conceptual design of the tailings facilities.

Mr. Buranek has experience in design work for several uranium, silver, gold, and phosphate tailings disposal projects. He has served as project engineer for design of a 180 ft. high tailings retention dam in Colorado, a large uranium tailings disposal facility in New Mexico, and he has designed four other earth dams (maximum height 155 ft.) for a uranium milling operation in New Mexico. This work has included direction of site selection in alternative studies and preparation of preliminary cost estimates, design reports, and construction plans and specifications, as well as permitting assistance with regulatory agencies.

RICHARD C. HOUSTON, Project Manager, Mountain States Engineering

Engineer of Mines Degree, Colorado School of Mines
M.B.A., University of Arizona
Registered Engineer - Colorado and Arizona

Mt. Hope Project: Responsible for direction of tailings distribution system development and water reclamation pipe and pump system evaluation.

Responsible as project engineer for numerous projects located in the Southwest. Responsible for design and construction of surface facilities for uranium mines, including hoisting plant and shaft dewatering systems. Supervised construction of all surface facilities associated with developing a 30,000 TPD molybdenum mine. Project manager for platinum paladium mine feasibility study.

CHARLES J. BENNETT, Environmental Specialist, Normandeau Associates, Inc.

B.A. in Geography, Middlebury Collage
M.A. in Geography, Syracuse University
Ph.D. in Geography, Syracuse University

Mt. Hope Project: Responsible for coordination and environmental assessments relevant to site selection process for a tailings facility.

Responsible for: baseline studies in mining reclamation plans for surface mines, Gillette, Wyoming; environmental and regulatory overview of an East Texas lignite mine; and a socio and economic land use baseline study for other East Texas mining prospect. Supervisor of Social Sciences, including supervision of Social Science components, including an EIS and a generating station and an alternate site in Kentucky.

ROBERT K. KENNEDY, Plant Ecologist, Normandeau Associates, Inc.

B.S. in Botany and Biology, South Dakota University
M.S. in Plant Ecology/Soils, Iowa State University
Ph.D. in Plant Ecology/Geography, University of Oklahoma

Mt. Hope Project: Responsible as a senior scientist for providing environmental assessments of alternative tailings sites during the site selection process for a tailings facility.

Professional experience includes project direction staffing and business development related to energy development projects in the west, preparation of environmental impact statements covering coal mine development of two electric generating units, and a 500 kV transmission line corridor in Montana. Also assumed technical direction of plan ecology studies, including field and laboratory sampling and analysis interpretation of vegetation data and report preparation. Designed and directed an environmental assessment study of cooling tower salts on vegetation and soils in a 12,000 acre area of Southwest Indiana.

CHAPTER 5.0
TOPOGRAPHY AND GEOLOGY GLOSSARY

Adit. A horizontal gallery or opening driven from the surface which gives access to the ore body. The term "tunnel" is frequently used in place of adit, but, technically, a tunnel is open to the surface at both ends.

Alluvial apron. The area of intermediate slope at the base of mountain ranges and composed of coalescing alluvial fans.

Alluvial fan. A fan-shaped deposit of sand, gravel and fine material dropped by a stream where its gradient lessens abruptly. Usually found at the base of highland terrain in arid regions.

Alluvium. A general term for all detrital material deposited or in transit by streams, including gravel, sand, silt, clay and all variations and mixtures of these.

Alteration. Change in the minerological composition of a rock, typically brought about by the action of hydrothermal solutions. Sometimes classed as a phase of metamorphism but usually distinguished from it because of a milder and more localized nature.

Andesite. A volcanic rock composed essentially of andesine and one or more mafic constituents. Pyroxene, hornblende, or biotite or all three in various proportions may constitute the mafic constituents.

Aplitic. A fine-grained granitic texture characteristic of certain igneous rocks.

Aquifer. A formation, group of formations, or part of a formation that is water bearing.

Argillite. A rock derived either from siltstone, claystone, or shale, that has undergone a somewhat higher degree of induration than is present in those rocks. (Twenhofel, W.H., Rept. Comm. Sed., pp. 95-96 1936-1937)

Ash flow. A volcanic deposit resulting from an avalanche of volcanic ash and other debris; generally a highly heated mixture of volcanic gases and ash, traveling down the flanks of a volcano or along the surface of the ground and produced by the explosive emission of gas-charged ash from a fissure or group of fissures or by the explosive disintegration of viscous lava in a volcanic crater.

Bajada. The joining together of many alluvial fans to make a continuous apron-like feature of sediment.

Basal unit. Of, pertaining to, located at, or forming a base. The bottom member of a formation.

Basalt. A hard, dense, dark volcanic rock composed chiefly of plagioclase, augite and magnetite and often having a glassy appearance.

Batholith. A stock-shaped or shield-shaped mass of igneous rock intruded as the fusion of older formations and of considerable size. (Suess, 1895)

Biotite. A mineral, a member of the mica group. A common rock-forming mineral usually dark brown to green.

Block faulting. See Fault block.

Brachiopod. A marine shelled animal with two unequal shells or valves each of which normally is bilaterally symmetrical. Also called "lamp shells."

Breccia. A fragmental rock whose components are coarse angular fragments and therefore, as distinguished from conglomerates, are not waterworn. There are sedimentary breccias, friction or fault breccias, talus breccias and eruptive breccias. (Kemp)

Calcareous. Containing calcium carbonate ($CaCo_3$).

Calc-silicate = skarn. Metamorphosed rock containing calcium carbonate ($CaCO_3$), mainly calcite and calcium bearing silicates.

Caldera. A large basin-shaped volcanic depression, more or less circular in form, the diameter of which is many times greater than that of the included volcanic vent or vents. (After Williams, H., Univ. Calif. Dept. Geol. Sci. Bull., vol. 25, pp. 242-246, 1941)

Cambrian. The oldest of the systems into which the Paleozoic stratified rocks are divided; also the corresponding geologic period.

Carbonate. A salt or ester of carbonic acid; a rock containing the radical CO_3, such as limestone or dolomite.

Cenozoic. The latest of the four eras into which geologic time, as recorded by the stratified rocks of the earth's crust, is divided; it extends from the close of the Mesozoic era to and including the present. Also the whole group of stratified rocks deposited during the Cenozoic era. The Cenozoic era includes the periods called Tertiary and Quaternary in the nomenclature of the U.S. Geological Survey; some European authorities divide it, on a different basis, into the Paleogene and Neogene periods, and still others extend the Tertiary period to include the whole. (La Forge)

Chalcopyrite. Copper pyrites. A mineral, $CuFeS_2$. Tetragonal. An important ore of copper.

Chert. Sedimentary rock composed of exceedingly fine-grained quartz and opal.

Chlorite. A platy hydrous silicate of aluminum, ferrous iron and magnesium which is closely related to iron. Usually green in color and common in low-grade metamorphic rocks.

Clastic. 1. In petrology, a textural term applied to rocks composed of fragmental material derived from pre-existing rocks or from the dispersed consolidation products of magmas or lavas. (Holmes, A., p. 60, 1920) 2. A clastic rock is one composed principally of detritus transported mechanically into its place of deposition. It may consist of material that was originally chemically or biogenetically deposited within the same basin, provided it was moved as particles before its final deposition. The commonest clastics are sandstones and shales as distinct from linestones and anhydrites. However, limestones formed from particles derived from pre-existing limes are clastic. (AAPG, 1949)

Claystone. Applicable to indurated clay in the same sense as sandstone is applicable to indurated or cemented sand. Rocks in which much clay is present or which are largely composed of clay sometimes bound together by iron carbonate. (Grabau, Textbook of Geol., p. 580, 1920)

Conglomerate = Puddingstone. 1. Rounded water-worn fragments of rock or pebbles, cemented together by another mineral substance, which may be of a siliceous or argillaceous nature. This is locally termed "pudding stone." (Roberts, G., Etymol. and Explan. Dict. Geol., p. 34, 1839) 2. A cemented clastic rock containing rounded fragments corresponding in their grade sizes to gravel or pebbles. Monogenetic and polygenetic types are recognized, according to the uniformity or variability of the composition and source of the pebbles. (Holmes, 1928)

Contact. 1. The place or surface where two different kinds of rocks come together. Although used for sedimentary rocks, as the contact between a limestone and sandstone, it is yet more especially employed as between igneous intrusions and their walls. The word is of wide use in western mining regions on account of the frequent occurrence of ore bodies along contacts. (Kemp)

Contact metamorphism. Metamorphism genetically related to the intrusion or extrusion of magmas and taking place in rocks at or near their contact with a body of igneous rock.

Country rock. A general term applied to the rocks invaded by and surrounding an igneous intrusion. (After Holmes, A., 1920)

Cretaceous. The third and latest of the periods included in the Mesozoic era; also the system of strata deposited in the Cretaceous period. (La Forge)

Dacite. The extrusive equivalent of quartz diorite; the principal minerals are plagioclase, quartz, pyroxene and/or hornblende with minor amounts of biotite and sanidine.

Detrital = Clastic, q.v. = Allogenic, q.v. Said of minerals occurring in sedimentary rocks, which were derived from preexisting igneous, sedimentary or metamorphic rocks. (After Twenhofel, Prin. Sed., p. 284, 1950)

Devitrification. The process by which glassy rocks break up into definite minerals. The latter are usually excessively minute crystals of quartz and feldspar. (Kemp) The change from a glassy to a crystalline state after solidification.

Devonian. In the ordinarily accepted classification, the fourth in order of age of the periods comprised in the Paleozoic era, following the Silurian and succeeded by the Mississippian. Also the system of strata deposited at that time. (La Forge) Sometimes called the Age of Fishes.

Dike. 1. A tabular body of igneaous rock that cuts across the structure of adjacent rocks or cuts massive rocks. Although most dikes result from the intrusion of magma, some are the result of metasomatic replacement. 2. A wall or mound built around a low-lying area to prevent flooding. (BEB 2)

Dip. The angle at which a stratum or any planar feature is inclined from the horizontal.

Dolomite. Sedimentary rock or mineral composed primarily of the mineral dolomite $[Ca\,Mg\,(CO_3)_2]$.

Drift. A horizontal underground opening driven along the course of a vein. It does not necessarily have to be driven in the vein.

Effective peak ground acceleration = EPA. The measure of maximum acceleration of the ground surface (rock) during a seismic event; usually referred to as the ground acceleration.

Eocene. The second epoch of the Cenozoic era, dating from ca. 58 to 34 million years ago.

Epidote. A mineral, $Ca_2\,(Al,\,Fe^{111})_3\,(Si\,O_4)_3,\,(OH)$, commonly found in metamorphic rocks.

Epicenter. The point on the earth's surface directly above the focus of an earthquake.

Epoch. The time subdivisions of periods on the geologic timescale.

Era. In geology, in general a large division of geologic time; specifically, a division of geologic time of the highest order, comprising one or more periods. The eras now generally recognized are the Archeozoic, Proterozoic, Paleozoic, Mesozoic, and Cenozoic. (La Forge) The Am. Comm. Strat. Nomenclature recommends (1954) that Early Precambrian be substituted for Archeozoic and Late Precambrian for Proterozoic.

Erosion. The group of processes whereby earthy or rock material is loosened or dissolved and removed from any part of the earth's surface. It includes the processes of weathering, solution, corrasion, and transportation. The mechanical wear and transportation are effected by running water, waves, moving ice, or winds, which use rock fragments to pound or grind other rocks to powder or sand. (Ransome, F. L., USGS Prof. Paper 115, p. 182, 1919)

Eugeosyncline. A long, narrow geosyncline in which volcanic rocks are abundant. (Kay, 1951)

Evaporite. One of the sediments which are deposited from aqueous solution as a result of extensive or total evaporation of the solvent. (Rankama and Sahama, p. 199; used first by Berkey, C.B., Bull. N.Y. Mus., vol. 251, p. 105, 1924)

Extrusive. A term applied to those igneous rocks derived from magmas or magmatic materials poured out or ejected at the earth's surface. Synonymous with effusive rocks, volcanic rocks.

Fault. A fracture or fracture zone along which there has been displacement of the two sides relative to one another parallel to the fracture. The displacement may be a few inches or many miles. (Reid, 1913)

Feldspar. A group of abundant rock-forming minerals; see Microcline, Orthoclase, Plagioclase, Anorthoclase.

Fissure. 1. An extensive crack, break, or fracture in the rocks. A mere joint or crack persisting only for a few inches or a few feet is not usually termed a fissure by geologists or miners, although in a strict physical sense it is one. (Ransome)

Flood plain. Nearly level land, consisting of stream sediments, that borders a stream and is subject to flooding unless protected artificially.

Formation. "In geology, any assemblage of rocks which have some character in common, whether of origin, age, or composition." (Lyell, Manual of Geol. 6th Ed., p. 2, 1858)

Geanticline. A broad uplift, generally referring to the land mass from which sediments in a geosyncline are derived. Originally used by J. D. Dana in 1873 as a synonym of anticlinorium and the opposite of synclinorium. (Struc. Comm.)

Geosyncline. A large elongate basin within which great thicknesses of sedimentary and volcanic rocks are accumulating due to a regional extent of subsidence over a long time. Geosynclines are prevalently linear, but non-linear depressions can have properties that are essentially geosynclinal. (After Kay, p. 4, 1951; first used by J.D. Dana in 1873)

Granite. 1. A plutonic rock consisting essentially of alkalic feldspar and quartz. Sodic plagioclase, usually oligoclase is commonly present in small amounts and muscovite, biotite, hornblende, or rarely pyroxene may be mafic constituents. 2. In seismology, a rock in which velocity of the compressional wave lies somewhat between 5.5 and 6.2 km/sec. (Burch, F., Nuclear Geology, p. 171)

Granodiorite. A plutonic rock consisting of quartz, calcic oligoclase or andesine, and orthoclase, with biotite, hornblende, or pyroxene as mafic constituents. Granodiorite is intermediate between quartz monzonite and quartz diorite and contains at least twice as much plagioclase as orthoclase.

Groundmass. The material between the phenocrysts in a porphyritic igneous rock. It includes the basis or base as well as the smaller crystals of the rock. Essentially synonymous with Matrix.

Hornfels. A fine-grained, non-schistose metamorphic rock resulting from contact metamorphism.

Host Rock. The wall rock of an ore deposit that has undergone a change in mineral characteristics due to outside influence.

Hydrothermal (adj.). A term applied to heated or hot magmatic emanations rich in water, to the processes in which they are concerned, and to the rocks, ore deposits, alteration products, and springs produced by them. (After Holmes, A., 1920)

Hypabyssal (adj.). A general term applied to minor intrusions such as sills and dikes, and to the rocks that compose them, which have crystallized under conditions intermediate between the plutonic and extrusive classes, being distinguished from these types in some cases by texture and in others only by mode of occurrence.

Igneous rock. Rock that has been formed by the cooling of molten mineral material. Examples: Granite, syenite, diorite, and gabbro.

Ignimbrite (n.). A type of silicic volcanic rock forming thick, massive, compact, lavalike sheets that cover a wide area in the central part of North Island, New Zealand. The rock is chiefly a fine-grained rhyolitic tuff formed mainly of glass particles (shards) in which crystals of fedlspar, quartz, and occasionally hypersthene or hornblende are embedded. The glass particles are firmly "welded" and bend around the crystals, and evidently were of a viscous nature when they were deposited. The deposits are believed to have been produced by the eruption of dense clouds of incandescent volcanic glass in a semi-molten or viscous state from groups of fissures. The term welded tuff is synonymous. (After Marshall, P., New Zealand Jour. Sci. and Tech., vol. 13, pp. 198-200, 1932)

Intrusive. Magma or plastic solid which penetrates in or between older rock and solidifies before reaching the surface.

Jurassic. In geology, the middle one of the three periods comprised in the Mesozoic era. Also the system of strata deposited during that period.

Lacustrine. Produced by or belonging to a lake environment. (Emmons, Ebeneyer, Man. of Geol., 1860)

Lava. Magma that has erupted onto the earth's surface, as from a volcano.

Lens. A body of ore or rock thick in the middle and thin at the edges; similar to a double convex lens.

Limestone. Sedimentary rock composed predominantly of calcite; Ca CO_3.

Lithophile elements. Elements enriched in the silicate crust. (Rankama and Sahama, p. 88) Elements with a greater free energy of oxidation, per gram atom of oxygen, than iron; they concentrate in the stony matter or slag crust of the earth, as oxides and more often as oxysalts, especially silicates. (Goldschmidt, p. 24, 1954)

Mafic. Refers to rocks or minerals rich in magnesium and iron; relatively.

Magma. Naturally occurring mobile rock material, generated within the earth and capable of extrusion and intrusion, from which igneous rocks are considered to have been derived by cooling and solidification.

Magnitude (earthquake). The Richter Magnitude Scale describes the maximum amount of ground movement measured at a fixed distance from an earthquake's focus. This scale ranges from 1 to 10.

Matrix. 1. In a rock in which certain grains are much larger than the others the grains of smaller size comprise the matrix. (AAPG, 1949) The groundmass of porphyritic igneous rocks. 2. The natural material in which any metal, fossil, pebble, crystal, etc. is embedded. (After Webster, New Int. Dict., 1948)

Mesozoic. One of the grand divisions or eras of geologic time, following the Paleozoic and succeeded by the Cenozoic era, comprising the Triassic, Jurassic, and Cretaceous periods. Also the group of strata formed during that era. (La Forge)

Metamorphosed. Rock having undergone any change in texture or chemical composition after its induration or solidification, produced by exterior agencies, especially by deformation (pressure), heat and moisture. (La Forge)

Miocene. The fourth of the five epochs of the Cenozoic era and into which the Tertiary period is divided; occurring between 22.5 and 5 million years ago. Also the series of strata deposited during that epoch.

Miogeosyncline. A long, narrow geosyncline in which volcanic rocks are rare or absent. (Kay, 1951)

Mississippian. Formerly the lower of two epochs into which Carboniferous was subdivided. Recently, the Am. Comm. Strat. Nomenclature recommended advancement to period rank, and that now accepted by U.S. Geol. Surv. In America, Mississippian is fifth of seven periods in the Paleozoic Era. Also the system of rocks found during the period.

Normal fault. A fault at which the hanging wall has been depressed, relative to the footwall. (Lindgren, p. 140, 1933)

Nuee ardente. A French term applied to a highly heated mass of gas-charged lava, more or less horizontally ejected from a vent or pocket at the summit of a volcano, onto an outer slope where it continues on its course as an avalanche, flowing swiftly, however slight the incline,

by virtue of its extreme mobility. The mobility of the mass is due to the disintegration of the lava into small, discrete particles and the envelopment of the particles in a highly compressed gaseous atmosphere, due largely to continuous vapor emission by the particles themselves. During the descent of the avalanche there is thus developed a violently expanding cloud of gas and ash, rolling upward in great cauliflower masses from the hidden avalanche along the ground which gives rise to it. Eruptions of this type exhibit a wide range of intensity, from the mere ejection of viscous lava out of a shallow pocket, breaking up into lava blocks that slide down a mountain slope, to a terrific horizontal blast of ash and lava fragments, traveling for miles with incredible swiftness - perhaps the most tremendous type of explosion found in present-day volcanoes. See Ash flow. (After Perret, F. A., Carnegie Inst. Wash., Pub. 458, p. 84, 1937)

Oligocene. The third epoch of the Cenozoic era and into which the Tertiary period is at present ordinarily divided, occurring from ca. 33 to 23 million years ago. Also the series of strata deposited during that epoch.

Olivine. A mineral silicate of iron and magnesium, principally Fe_2SiO_4 and Mg_2SiO_4, found in igneous and metamorphic rocks.

Ordovician. The second of the periods comprised in the Paleozoic era, in the geological classification now generally used. Also the system of strata deposited during that period. (La Forge) In older literature, it was called "Lower Silurian."

Orogeny. The process of formation of mountain ranges by folding, faulting and thrusting. (After Upham, W., four. Geol. 2, p. 383, 1894)

Orthoclase. A mineral, a member of the feldspar group. Composition $KAlSi_3O_8$. Monoclinic, dimorphous with microline. A common mineral of granite rocks. Abbr. Or.

Outcrop. A portion of bedrock or other stratum protuding through the soil level.

Paleozoic. One of the eras of geologic time that, between the Late Precambrian and Mesozoic eras, comprises the Cambrian, Ordovician, Silurian, Devonian, Mississippian, Pennsylvanian, and Permian systems. The beginning of the Paleozoic was formerly supposed to mark the appearance of life on the earth, but that is now known to be incorrect. Also the group of rocks deposited during the Paleozoic era.

Pediment. 1. Steep rock slopes having roughly triangular shapes resembling architectural pediments. (Dutton, Tertiary History of the Grand Canyon, Atlas Sheet 5, 1882) 2. Gently sloping plains eroded at the foot of steep slopes or cliffs. (McGee, W. J., GSA Bull. 8, p. 92, 1897) 3. (Composite) A planed rock surface adjoining a rugged-faced mountain mass, partly covered with a veneer of alluvium, which merges with the alluvial valley-plain. (McGee, GSA Bull., vol. 8, 92, 100, 1897)

Peraluminous. In the Shand classification of igneous rocks, a division embracing those rocks in which the molecular proportion of alumina exceeds that of soda, potash, and lime combined.

Permian. Formerly the last of the three epochs in the Carboniferous period. In recent years advanced to period rank by U.S. Geol. Surv. Now considered by Am. Comm. on Strat. Nomenclature as last of seven periods in Paleozoic Era. Also the system of rocks formed during the period.

Phenocryst. A porphyritic crystal; one of the relatively large and ordinarily conspicuous crystals of the earliest generation in a porphyritic igneous rock. (La Forge) A name suggested by J. P. Iddings, for porphyritic crystals in rocks. It has proved an extremely convenient one, although its etymology has been criticized. Shand has suggested the term inset in its place.

Plagioclase. A mineral group, formula $(Na,Ca)Al(Si,Al)Si_2O_8$; a solid solution series from $NaAlSi_3O_8$ (albite) to $CaAl_2Si_2O_8$ (anorthite). Triclinic. One of the commonest rock-forming minerals. Commonly the series is designated in terms of the mole fraction of the albite component (abbr. Ab) and anorthite component (An), as follows (Ab+An=100): albite (Ab 100-90), oligoclase (Ab 90-70), andesine (Ab 70-50), labradorite (Ab 50-30), bytownite (Ab 30-10), anorthite (Ab 10-0).

Playa. The shallow central basin of a desert plain or valley in which water gathers after a rain and is evaporated. (U.S. Geol. Surv., Bull. 613, p. 184)

Pleistocene. The earlier of the two epochs comprised in the Quaternary period, in the classification generally used. Also called Glacial epoch and formerly called Ice age, Post-Pliocene, and Post-Tertiary. Also the series of sediments deposited during that epoch, including both glacial deposits and ordinary sediments. Some geologists formerly used Pleistocene as synonymous with Quaternary and included in it all post-Tertiary time and deposits. (La Forge)

Pliocene. The latest of the epochs comprised in the Tertiary period, in the classification generally used. Also the series of strata deposited during that epoch. (La Forge)

Porphyry. Generally referring to all rocks containing conspicuous crystals in a fine-grained groundmass. (After Holmes, A., 1920)

Precambrian. All rocks formed before Cambrian time are now called Precambrian in Canada and by many geologists in the United States. The Am. Comm. on Strat. Nomenclature recommends that the Canadian spelling be used, that the terms Early Precambrian era and Late Precambrian era be substituted for Archean and Proterozoic.

Primary. 1. Characteristic of or existing in a rock at the time of its formation; said of minerals, textures, etc., of rocks; essentially the same as Original, and contrasted with Derived, or Secondary.

Pumice. An excessively cellular, glassy lava, generally of the composition of rhyolite. (Kemp) A sort of volcanic froth. Its color is generally whitish or light gray. It is very light and will float on water. Pumice stone. Economically useful as an abrasive.

Pyrite. Iron pyrites. Fool's gold. A mineral, FeS_2, dimorphous with marcasite. Isometric, commonly in striated cubes or in pyritohedrons. Brass yellow, hardness 6-6 1/2. An important ore of sulfur; sometimes mined for the associated gold or copper.

Pyroclastic. Fragmental or detrital material which has been expelled aerially from a volcanic vent.

Quartzite. 1. A granulose metamorphic rock consisting essentially of quartz. 2. Sandstone cemented by silica which has grown in optical continuity around each fragment. (After Holmes' Nomenclature of Petrology, p. 194, 1950) See: Arkose quartzite, Arkosite, Gneissic quartzite, Granulite, Graywacke quartzite, Slaty quartzite.

Quartz latite. The extrusive equivalent of a quartz monzonite. The principal minerals are quartz, sanidine, biotite, sodic plagioclase and often hornblende usually occurring as phenocrysts in a groundmass of potash feldspar and quartz (or tridymite-cristobalite), or glass. Accessory minerals are magnetite, apatite and zircon. With an increase in silica and alkalies the rock passes into a rhyolite and with a decrease in these constituents it passes into a dacite.

Quaternary. The younger of the two geologic periods or systems in the Cenozoic era. Quaternary is subdivided into Pleistocene and Recent epochs or series. It comprises all geologic time and deposits from the end of the Tertiary until and including the present. It has also been called Post-Tertiary and Pleistocene, but Pleistocene is now generally restricted to the earlier part of the Quaternary.

Recent. The later of the two geologic epochs comprised in the Quaternary period, in the classification generally used; same as Holocene. Also the deposits formed during that epoch. (The Holocene, or Recent, comprises all geologic time and deposits from the close of the Pleistocene or Glacial epoch until and including the present.) (La Forge)

Retrograde alteration. A term used to describe previously altered rocks which have been shifted into a new geologic environment, resulting in subsequent alteration and reducing them from a high rank alteration rock to a low rank alteration rock.

Rhyolite. The extrusive equivalent of a granite. The principal minerals being one or more of the silica minerals (e.g., quartz, alkali feldspar.

Sandstone. Variously colored sedimentary rock composed predominatly of sand-like quartz grains cemented by lime, silica, or other materials.

Secondary. 1. A general term applied to rocks and minerals formed as a consequence of the alteration of pre-existing minerals. Secondary or they may be deposited from solution in the interstices of a

rock through which the solution is percolating. (Holmes, 1928) 2. Formed of material derived from the erosion or disintegration of other rocks; derivative; said of clastic sedimentary rocks. 3. The output coil of a transformer.

Sericite. A fine-grained variety of mica occurring in small scales, especially in schists. Usually muscovite, but may consist of paragonite or hydrous micas.

Shaft. 1. An excavation of limited area compared with its depth, made for finding or mining ore or coal, raising water, ore, rock, or coal, hoisting and lowering men and lowering men and material, or ventilating underground workings. The term is often specifically applied to approximately vertical shafts, as distinguished from an incline or inclined shaft. 2. In speleology, a vertical passage.

Shale. 1. A laminated sediment, in which the constituent particles are predominantly of the clay grade. (Holmes, 1928) 2. Shale includes the indurated, laminated or fissile claystones and siltstones. The cleavage is that of bedding and such other secondary cleavage or fissility that is approximately parallel to bedding. The secondary cleavage has been produced by the pressure of overlying sediments and plastic flow. (Twenhofel, W. H., Rept. Comm. Sed., p. 98, 1936-1937)

Shearing. The deformation of rocks by the cumulation of small lateral movements along innumerable parallel planes, resulting from pressure.

Silica. Silicon dioxide, SiO_2.

Siliceous. Of or pertaining to silica; containing silica, or partaking of its nature. (Webster) Containing abundant quartz. Also spelled Silicious.

Silicic. 1. In petrology, containing silica in dominant amount. 2. In chemistry, containing silicon as the acid-forming element. (La Forge) = Felsic = Acid, 2,q.v.

Siltstone. A very fine-grained consolidated clastic rock composed predominantly of particles of silt grade. (AAPG, 1949)

Slope. 1. The inclined surface of a hill, mountain, plateau, plain, or any part of the surface of the earth; the angle at which such surfaces deviate from the horizontal. (Topog.) 2. In mining, an inclined passage driven from the dip of a coal vein. Compare Slant. (Steel)

Stock. A body of igneous rock that covers less than 40 square miles, has steep contacts (generally dipping outward) and generally being discordant. (Billings, 1954)

Stockwork (Germ., Stockwerk). An ore deposit of such a form that it is worked in floors or stories. It may be a solid mass of ore, or a rock mass so interpenetrated by small veins of ore that the whole must be mined together. Stockworks are distinguished from tabular or sheet-deposit (veins, beds), which have a small thickness in

CHAPTER 6.0
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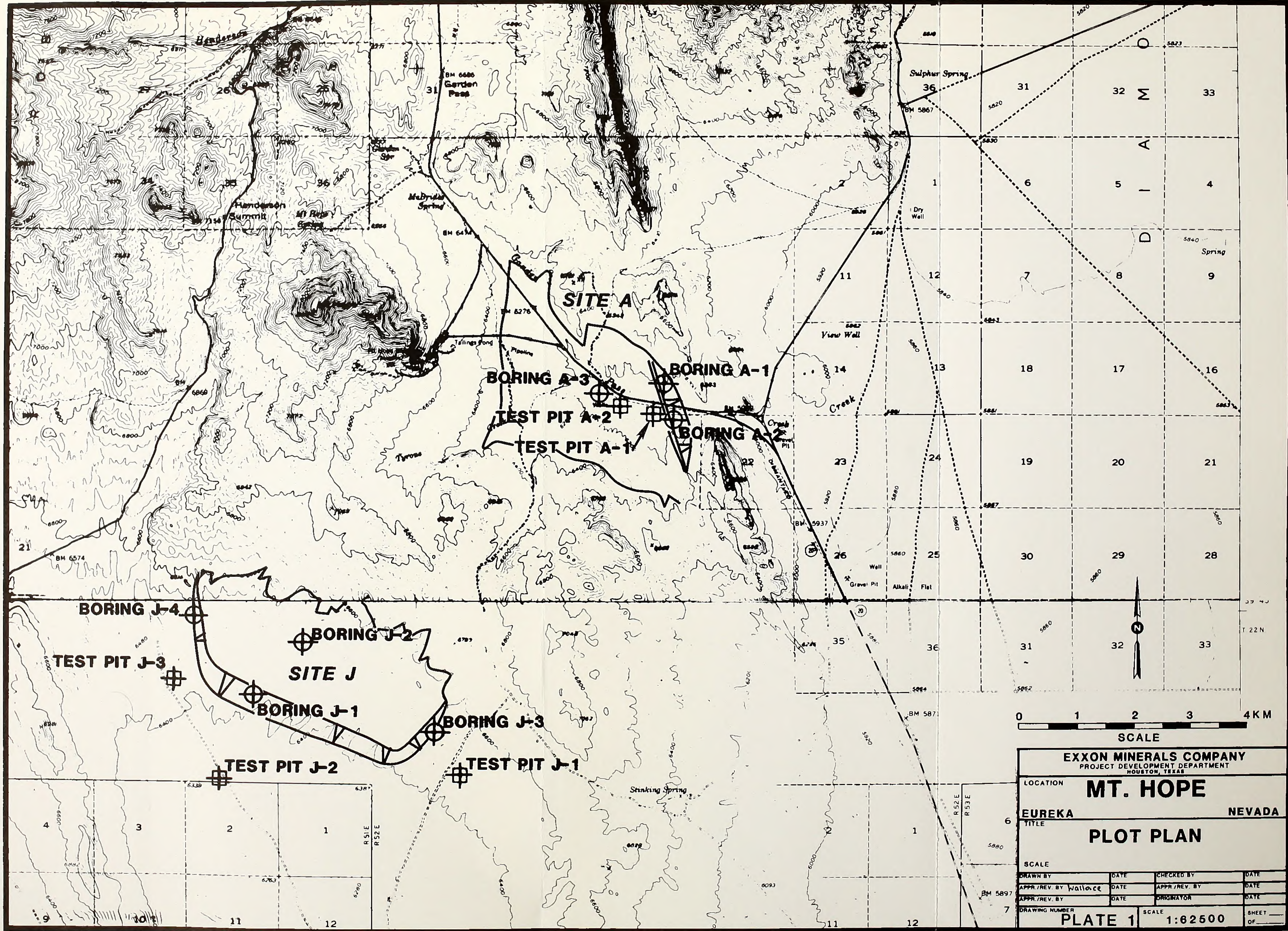
PRELIMINARY GEOTECHNICAL INVESTIGATION

OF ALTERNATE TAILINGS DISPOSAL SITES

MT. HOPE PROJECT

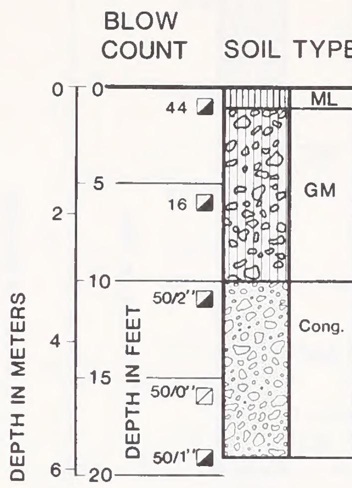
EUREKA, NEVADA


SITE A
BORING A-1
BORING A-2
BORING A-3
TEST PIT A-1
TEST PIT A-2
SITE J
BORING J-1
BORING J-2
BORING J-3
BORING J-4
TEST PIT J-1
TEST PIT J-2
TEST PIT J-3
Henderson Summit
Garden Pass
Sulphur Spring
McBride Spring
View Well
Tailings Pond
Stinking Spring
D I A M O
0 1 2 3 4 KM
SCALE
EXXON MINERALS COMPANY
PROJECT DEVELOPMENT DEPARTMENT
HOUSTON, TEXAS
LOCATION MT. HOPE
EUREKA NEVADA
TITLE PLOT PLAN
PLATE 1
SCALE 1:62500

483-3-99M1

BORING A-1

LABORATORY TEST DATA				
% FINES	ATTERBERG LIMITS LL-%	ATTERBERG LIMITS PI-%	NATURAL MOISTURE CONTENT-%	DRY UNIT WEIGHT -pcf-
8.0				

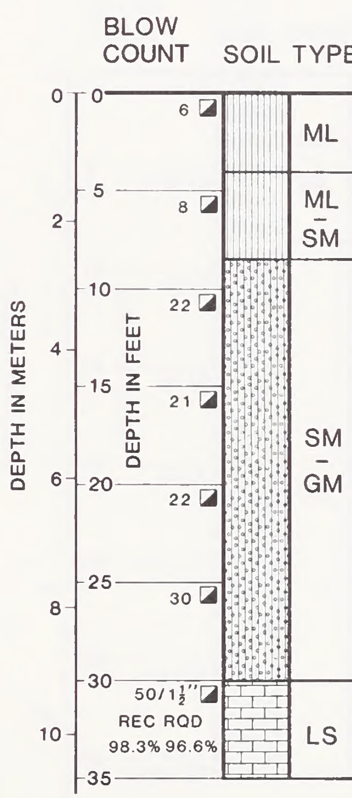


BLOW COUNT	SOIL TYPE	DESCRIPTION
44	ML	LIGHT BROWN FINE SANDY SILT - LOOSE
16	GM	BROWN FINE TO COARSE SUBANGULAR GRAVEL WITH SOME FINE TO COARSE SAND AND SILT - MEDIUM DENSE GRADING WITH OCCASIONAL SEAMS AND/OR ZONES OF BROWN SILTY, FINE TO COARSE SAND
50/2", 50/0", 50/1"	Cong.	BROWN SANDY, FINE TO COARSE PEBBLE CONGLOMERATE - SOFT

BORING COMPLETED AT 19'1" ON 9/8/82
NO GROUND WATER ENCOUNTERED

BORING A-2

52.8				
12.3				
			5.1	
			7.1	



BLOW COUNT	SOIL TYPE	DESCRIPTION
6	ML	LIGHT BROWN FINE SANDY SILT - SLIGHT PINHOLE STRUCTURE ROOTS TO 10" - LOOSE
8	ML - SM	BROWN SILT AND FINE SAND - LOOSE GRADING WITH FEW FINE TO MEDIUM SUBANGULAR GRAVELS
22, 21, 22, 30	SM - GM	BROWN SILTY, FINE TO COARSE SAND AND FINE TO COARSE SUBANGULAR GRAVEL - MEDIUM DENSE GRADING WITH MORE GRAVEL GRADING WITH OCCASIONAL ALTERNATING SAND AND GRAVEL LAYERS GRADING WITH OCCASIONAL COBBLES
50/1½" REC RQD 98.3% 96.6%	LS	GRAY FINE-GRAINED, SANDY LIMESTONE WITH OCCASIONAL SEAMS OF CALCITE - MODERATELY JOINTED - HARD

BORING COMPLETED AT 35' ON 9/8/82
NO GROUND WATER ENCOUNTERED

KEY:

32 ◪ STANDARD PENETRATION TEST SAMPLE
└── STANDARD PENETRATION RESISTANCE
◪ STANDARD PENETRATION TEST PERFORMED WITH NO SAMPLE RECOVERED

EXXON MINERALS COMPANY
HOUSTON — TEXAS

LOG OF BORINGS

PREPARED BY	JFW	DATE	11/82
DRAFTED BY	IM		

PLATE 2A

BORING J-3

LABORATORY TEST DATA				
%FINES	ATTERBERG LIMITS		NATURAL MOISTURE CONTENT-%	DRY UNIT WEIGHT -pcf-
	LL-%	PI-%		
11.0				

DEPTH IN FEET	BLOW COUNT	SOIL TYPE	DESCRIPTION
0	9	SM	BROWN FINE TO COARSE SAND WITH SOME SILT AND SOME ANGULAR FINE TO COARSE GRAVEL - LOOSE
5	29		GRADING DENSE
10	20		GRADING MEDIUM DENSE
15	170	SM	TAN SILTY FINE TO MEDIUM SAND WITH LITTLE FINE TO MEDIUM SUBANGULAR GRAVEL - SLIGHT PINHOLE STRUCTURE - VERY DENSE
20	50/1½	LS	DARK GRAY DOLOMITIC LIMESTONE - MODERATELY FRACTURED, SLIGHTLY WEATHERED - HARD
25	120/6"		BORING COMPLETE AT 25' ON 9/10/82 NO GROUND WATER ENCOUNTERED

DEPTH IN METERS: 0, 2, 4, 6, 8

BORING J-4

%FINES	LL-%	PI-%	NATURAL MOISTURE CONTENT-%	DRY UNIT WEIGHT -pcf-
44.7			10.0	118.9
38.5	39.9	16.5	12.2	116.3
			10.0	

DEPTH IN FEET	BLOW COUNT	SOIL TYPE	DESCRIPTION
0	12	SM - ML	BROWN FINE TO COARSE SAND AND SILT WITH OCCASIONAL FINE TO COARSE SUBANGULAR GRAVEL - MEDIUM DENSE
5	63		GRADING DENSE TO VERY DENSE
10	105	SC	BROWN FINE TO COARSE SAND WITH SOME SILTY CLAY AND SOME FINE TO COARSE SUBANGULAR GRAVEL - VERY DENSE
15	91		
20	82		
25			
30	111		
35	50/3"		BORING COMPLETE AT 35'9" ON 9/12/82 NO GROUND WATER ENCOUNTERED
40			

DEPTH IN METERS: 0, 2, 4, 6, 8, 10, 12

NOTE: SEE PLATE 2A FOR KEY

EXXON MINERALS COMPANY
HOUSTON, TEXAS

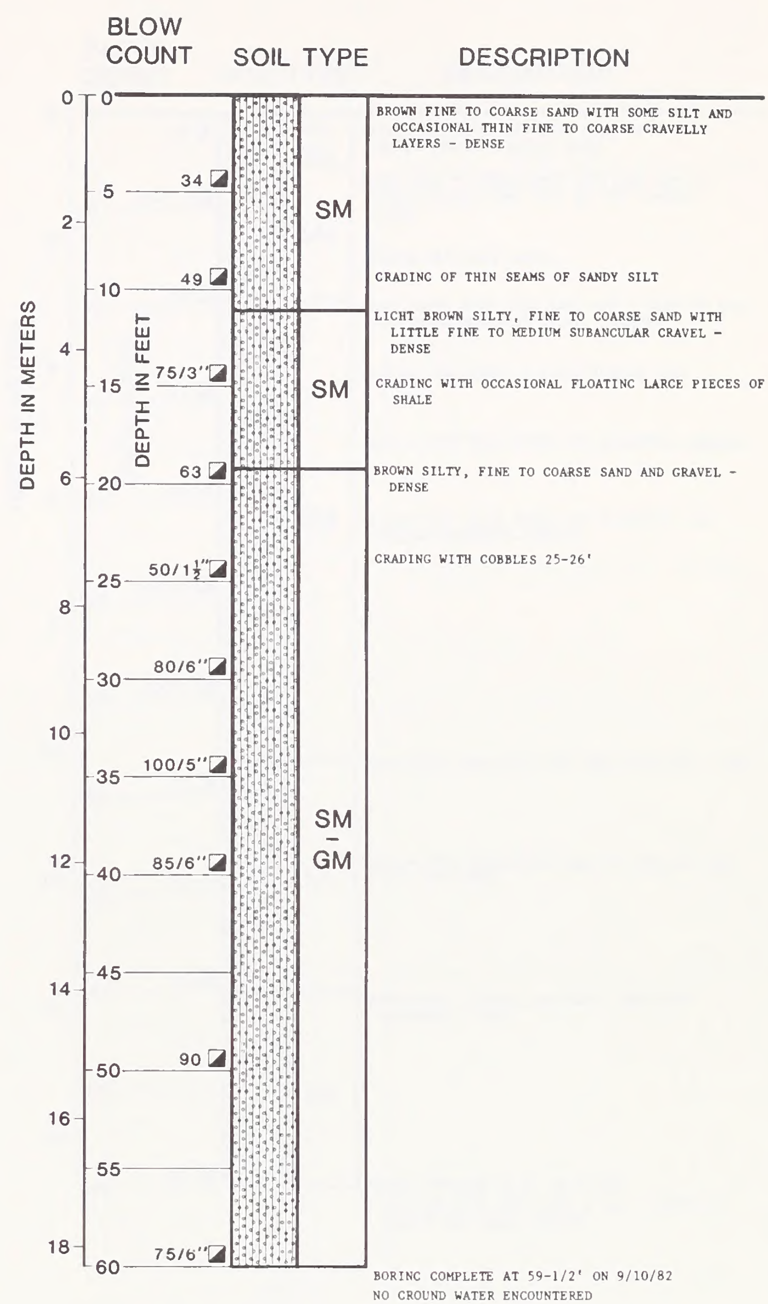
LOG OF BORINGS

PREPARED BY: JFW	DATE: 11/82	REVISED	MAP NO: PLATE 2B
DRAFTED BY: IM	DATE: 11/82	REVISED	

BORING J-1

LABORATORY TEST DATA

% FINES	ATTERBERG LIMITS LL-%	ATTERBERG LIMITS PI-%	NATURE MOISTURE CONTENT-%	DRY UNIT WEIGHT -pcf-
21.9				
			9.0	117.2
			9.0	117.2

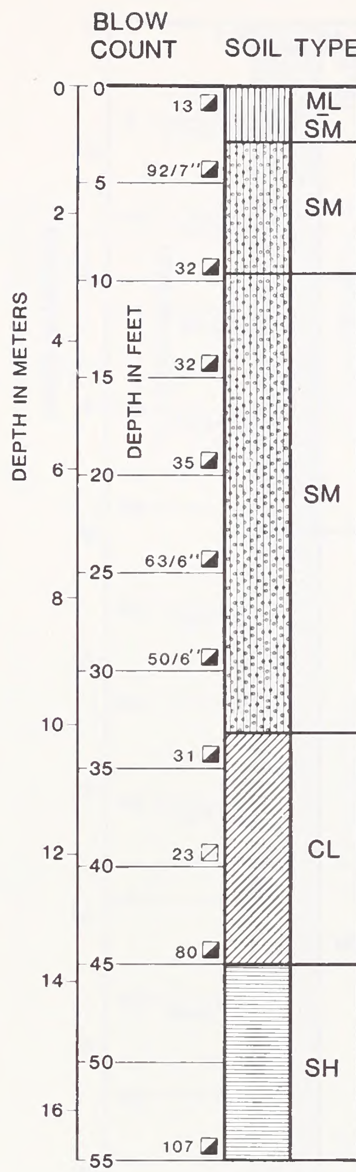


NOTE: SEE PLATE 2A FOR KEY

EXXON MINERALS COMPANY	
HOUSTON	TEXAS
LOG OF BORINGS	
PREPARED BY JFW	DATE 11/82
DRAFTED BY IM	PLATE 2C

BORING A-3

LABORATORY TEST DATA				
% FINES	ATTERBERG LIMITS LL-%	ATTERBERG LIMITS PI-%	NATURAL MOISTURE CONTENT-%	DRY UNIT WEIGHT -pcf-
40.4			15.3	
28.3			8.6	
	38.2	17.2		



DESCRIPTION

BROWN FINE SANDY SILT WITH TRACE FINE TO MEDIUM GRAVEL - MEDIUM DENSE

BROWN FINE TO COARSE SAND WITH SOME FINE TO COARSE GRAVEL, SOME SILT AND FEW COBBLES - DENSE

GRADING WITH LESS GRAVEL

LIGHT BROWN SILTY FINE SAND WITH A TRACE OF CLAY AND OCCASIONAL FINE GRAVEL - DENSE

GRADING GRAY-BROWN IN COLOR WITH NO CLAY

GRADING WITH MORE GRAVEL AND OCCASIONAL COBBLES

GRADING WITH SILTY ZONES AND OCCASIONAL SUB-ANGULAR WEATHERED COBBLES

GRAY BROWN SILTY CLAY WITH SOME FINE SAND - HARD

GRADING WITH OCCASIONAL ZONES OF GRAVELLY SAND 6" to 8" THICK

BLACK SHALE, HIGHLY FRACTURED, MODERATELY WEATHERED - SOFT

BORING COMPLETE AT 60' ON 9/9/82

1-1/2" PVC WELL INSTALLED TO 60' - LOWER 20' SLOTTED AND GRAVEL PACKED

NOTE: SEE PLATE 2A FOR KEY

EXXON MINERALS COMPANY
HOUSTON TEXAS

LOG OF BORINGS

PREPARED BY JFW DATE 11/82
DRAFTED BY IM
PLATE 2D

BORING J-2

LABORATORY TEST DATA

% FINES	ATTERBERG LIMITS LL-%	ATTERBERG LIMITS PI-%	NATURAL MOISTURE CONTENT-%	DRY UNIT WEIGHT -pcf-
	22.8	3.0	9.8	117.3
	NON-PLASTIC		7.0	
			5.1	

Log

DEPTH IN METERS: 0, 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22

DEPTH IN FEET	BLOW COUNT	SOIL TYPE	DESCRIPTION
0	7	ML SM	BROWN FINE SAND AND SILT - LOOSE
		SM - GM	BROWN FINE TO COARSE SAND AND FINE TO COARSE GRAVEL WITH SOME SILT - SLIGHT PINHOLE STRUCTURE TO 2-1/2" - LOOSE
5	110/9"	SM - ML	BROWN FINE TO MEDIUM SAND AND SILT WITH TRACE CLAY - VERY DENSE
10	70/3"		
15	70/3"		HARD LAYER FROM 17 - 17-1/2'
20	70/6"		
25		ML	BLACK FINE SANDY SILT (COMPLETELY WEATHERED SILTSTONE) - VERY HARD
30	75/3"		
35			HARD ZONES ENCOUNTERED BETWEEN 34-35'
40	70/6"		
45			
50	60/6"		THIN SEAM OF GRAY LIMESTONE 2-3" THICK AT 51'
55			
60			
65			
70	65/6"		BORING COMPLETE AT 71' ON 9/11/82
			NO GROUND WATER ENCOUNTERED

NOTE: SEE PLATE 2A FOR KEY

EXXON MINERALS COMPANY

HOUSTON TEXAS

TITLE: **LOG OF BORINGS**

STATE | C.I. | SCALE

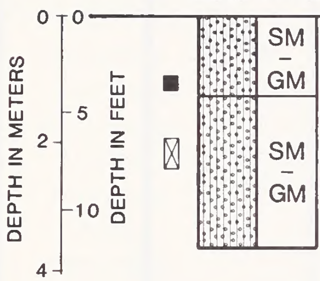
COUNTY | LEVEL | (ELEV.)

PREPARED BY JFW | DATE 11/82 | REVISED

DRAFTED BY IM | DATE | REVISED

MAP NO PLATE 2E

TEST PIT A-1



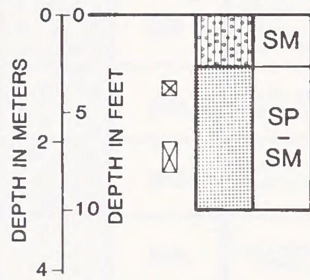
DESCRIPTION

BROWN, SILTY, FINE-TO-MEDIUM SAND AND FINE-TO-COARSE SUBANGULAR GRAVEL; MAJOR ROOTS TO A DEPTH OF 12 INCHES WITH MINOR ROOT NETWORK TO 5 TO 6 FEET, MINOR PIN-HOLE STRUCTURE TO A DEPTH OF 3.5 FEET -- LOOSE-TO-MEDIUM DENSE

INTERBEDDED BROWN, SILTY, FINE-TO-MEDIUM SAND AND FINE-TO-COARSE SANDY SUBANGULAR GRAVEL--MEDIUM DENSE

TEST PIT COMPLETE AT 12 FEET ON 10/12/82 -- NO GROUND WATER ENCOUNTERED

TEST PIT J-1



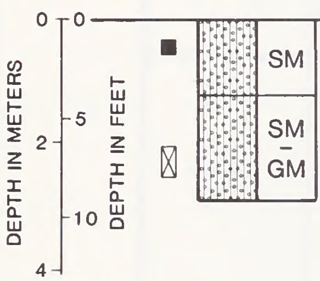
DESCRIPTION

DARK BROWN, SILTY, FINE-TO-COARSE SAND WITH TRACE FINE-TO-COARSE SUBANGULAR GRAVEL --MEDIUM DENSE

LIGHT BROWN FINE-TO-COARSE SAND WITH LITTLE CLAYEY SILT AND SOME FINE-TO-COARSE SUBANGULAR GRAVEL -- DENSE

TEST PIT COMPLETE AT 10 FEET ON 10/12/82 -- NO GROUND WATER ENCOUNTERED

TEST PIT A-2

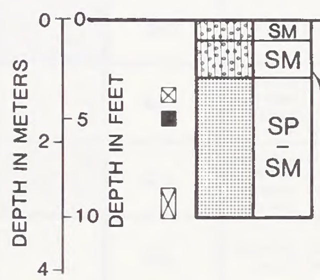


BROWN, SILTY, FINE-TO-COARSE SAND WITH SOME FINE-TO-COARSE GRAVEL; ROOT PENETRATION TO 18 INCHES -- LOOSE

INTERBEDDED SILTY, FINE-TO-COARSE SAND WITH SOME FINE-TO-COARSE SUBANGULAR GRAVEL AND FINE-TO-COARSE SANDY GRAVEL -- MEDIUM DENSE

TEST PIT COMPLETE AT 8 FEET ON 10/12/82 -- NO GROUND WATER ENCOUNTERED

TEST PIT J-2



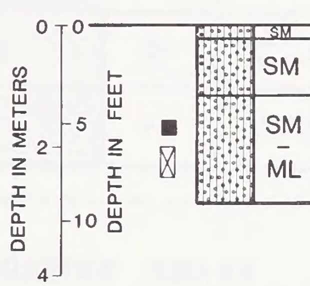
DARK BROWN, SILTY, FINE-TO-MEDIUM SAND WITH TRACE CLAY, OCCASIONAL FINE-TO-COARSE SUBANGULAR GRAVELS, ROOTS THROUGHOUT --LOOSE.

BROWN SILTY, FINE-TO-MEDIUM SAND WITH LITTLE FINE-TO-COARSE SUBANGULAR GRAVEL, TRACE CLAY -- LOOSE (SLIGHT PINHOLE STRUCTURE)

BROWN FINE-TO-COARSE SAND WITH LITTLE FINE-TO-COARSE SUBANGULAR GRAVEL AND LITTLE SILT --DENSE (OCCASIONAL MODERATELY CEMENTED ZONES)

TEST PIT COMPLETE AT 10 FEET ON 10/12/82 -- NO GROUND WATER ENCOUNTERED

TEST PIT J-3



DARK BROWN, SILTY, FINE SAND, WELL-DEVELOPED ROOT NETWORK -- LOOSE

BROWN SILTY, FINE-TO-MEDIUM SAND WITH LITTLE FINE-TO-COARSE SUBANGULAR GRAVEL -- LOOSE

BROWN FINE-TO-MEDIUM SAND AND SILT WITH TRACE CLAY (WELL-DEVELOPED PINHOLE STRUCTURE) -- LOOSE

TEST PIT COMPLETE AT 9 FEET ON 10/12/82 -- NO GROUND WATER ENCOUNTERED

KEY:

■ DEPTH AT WHICH UNDISTURBED SAMPLE WAS EXTRACTED

⊠ DEPTH AT WHICH DISTURBED SAMPLE WAS EXTRACTED

⊠ BULK SAMPLE

EXXON MINERALS COMPANY

HOUSTON TEXAS

LOG OF TEST PITS

STATE	C.	SCALE	
COUNTY	LEVEL (ELEV.)		
PREPARED BY	DATE	REVISED	MAP NO.
DRAFTED BY	DATE	REVISED	PLATE 3

MAJOR DIVISIONS			GRAPH SYMBOL	LETTER SYMBOL	TYPICAL DESCRIPTIONS
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	CLEAN GRAVELS (LITTLE OR NO FINES)		GW	WELL-GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES
				GP	POORLY-GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES
	MORE THAN 50% OF COARSE FRACTION <u>RETAINED</u> ON NO. 4 SIEVE	GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES)		GM	SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES
				GC	CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES
	SAND AND SANDY SOILS	CLEAN SAND (LITTLE OR NO FINES)		SW	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
MORE THAN 50% OF MATERIAL IS <u>LARGER</u> THAN NO. 200 SIEVE SIZE				SP	POORLY-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
	MORE THAN 50% OF COARSE FRACTION <u>PASSING</u> NO. 4 SIEVE	SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)		SM	SILTY SANDS, SAND-SILT MIXTURES
				SC	CLAYEY SANDS, SAND-CLAY MIXTURES
FINE GRAINED SOILS	SILTS AND CLAYS	LIQUID LIMIT <u>LESS</u> THAN 50		ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY
				CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
				OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
MORE THAN 50% OF MATERIAL IS <u>SMALLER</u> THAN NO. 200 SIEVE SIZE	SILTS AND CLAYS	LIQUID LIMIT <u>GREATER</u> THAN 50		MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILTY SOILS
				CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS
				OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
HIGHLY ORGANIC SOILS				PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

NOTE: DUAL SYMBOLS ARE USED TO INDICATE BORDERLINE SOIL CLASSIFICATIONS.

SOIL CLASSIFICATION CHART

UNIFIED SOIL CLASSIFICATION SYSTEM

ROCK QUALITY

Description Of Rock Quality	RQD* (Rock Quality Designation) (Percent)
Very Poor	0 to 25
Poor	25 to 50
Fair	50 to 75
Good	75 to 90
Excellent	90 to 100

JOINT SPACING

Joint Description	Spacing - Inches
Fissured	<0.24
Shattered	0.24 to 0.8
Very Close	0.8 to 2.4
Close	2.4 to 8.0
Moderate	8.0 to 24.0
Wide	24.0 to 80.0
Very Wide	>80.0

ROCK HARDNESS

Soft - Can be gouged deeply or carved with a pocket knife.

Moderately Hard - Can be readily scratched with knife blade. Scratch leaves heavy trace of dust and is readily visible after the powder has been blown away.

Hard - Can be scratched with difficulty; scratch produced little powder and is often faintly visible.

Very Hard - Cannot be scratched with pocket knife.

WEATHERING

Fresh - Rock fresh, crystals bright, few joints may show slight staining. Rock rings under hammer if crystalline.

Very Slight - Rock generally fresh, joints stained, some joints may show thin clay coatings, crystals in broken face show bright. Rock rings under hammer if crystalline.

Slight - Rock generally fresh, joints stained, and discoloration extends into rock up to one inch. Joints may contain clay. In granitoid rocks some occasional feldspar crystals are dull and discolored. Crystalline rocks ring under hammer.

Moderate - Significant portions of rock show discoloration and weathering effects. In granitoid rocks, most feldspars are dull and discolored; some show clayey. Rock has dull sound under hammer and shows significant loss of strength as compared with fresh rock.

Moderately Severe - All rock except quartz discolored or stained. In granitoid rocks, all feldspars dull and discolored and majority show kaolinization. Rock shows severe loss of strength and can be excavated with geologist's pick. Rock goes "clunk" when struck.

Severe - All rock except quartz discolored or stained. Rock "fabric" clear and evident, but reduced in strength to strong soil. In granitoid rocks, all feldspars kaolinized to some extent. Some fragments of strong rock usually left.

Very Severe - All rock except quartz discolored or stained. Rock "fabric" discernible, but mass effectively reduced to "soil" with only fragments of strong rock remaining.

Complete - Rock reduced to "soil." Rock "fabric" not discernible or discernible only in small scattered locations. Quartz may be present as dikes or stringers.

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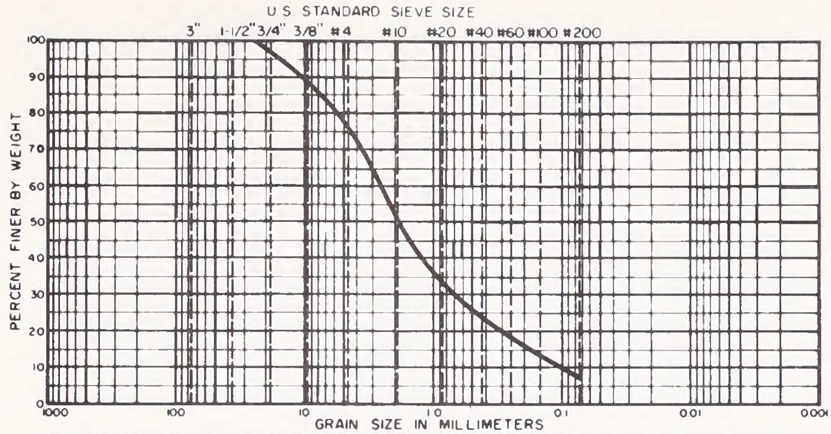
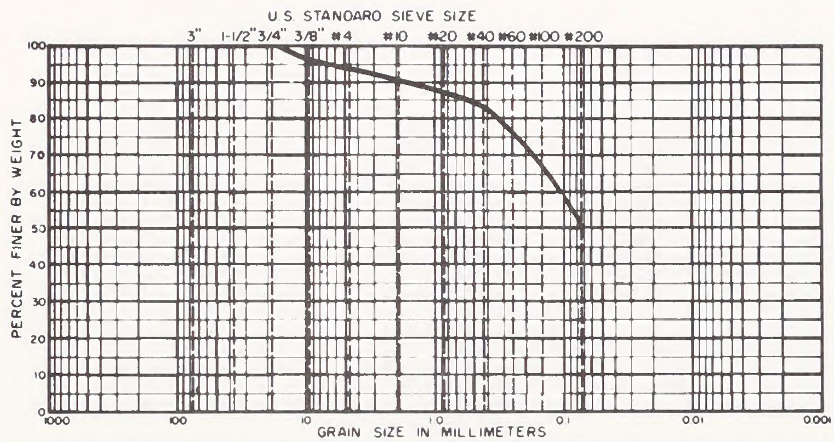
* RQD - The percentage of a core run with an unfractured length of four inches or more.

GEOTECHNICAL TERMINOLOGY FOR ROCK DESCRIPTION



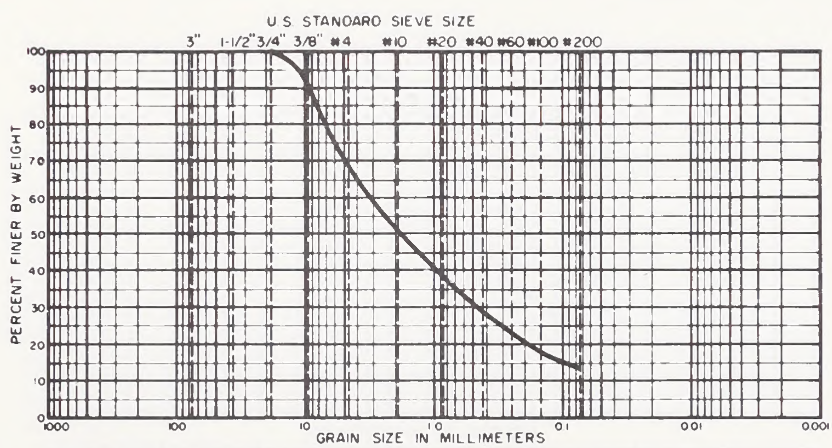
COBBLES	GRAVEL COARSE	GRAVEL FINE	SAND COARSE	SAND MEDIUM	SAND FINE	SILT OR CLAY

LOCATION	DEPTH	CLASSIFICATION
BORING A-1	**5 1/2-6ft.**	**SP/SM**



COBBLES	GRAVEL COARSE	GRAVEL FINE	SAND COARSE	SAND MEDIUM	SAND FINE	SILT OR CLAY

LOCATION	DEPTH	CLASSIFICATION
BORING A-2	**5 1/2-6ft.**	**ML/SM**



COBBLES	GRAVEL COARSE	GRAVEL FINE	SAND COARSE	SAND MEDIUM	SAND FINE	SILT OR CLAY

LOCATION	DEPTH	CLASSIFICATION
BORING A-2	**15 1/2-16ft.**	**SM/GM**

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HOUSTON, TEXAS

LOCATION
MT. HOPE PROJECT

TITLE
GRAIN-SIZE DISTRIBUTIONS

SCALE

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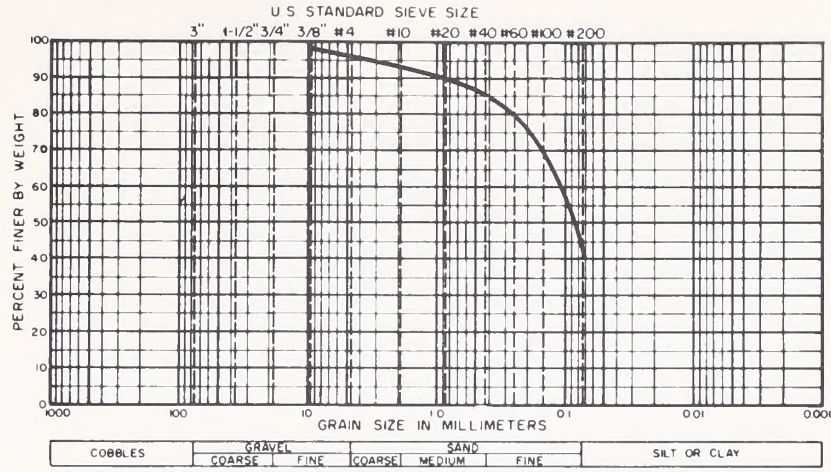
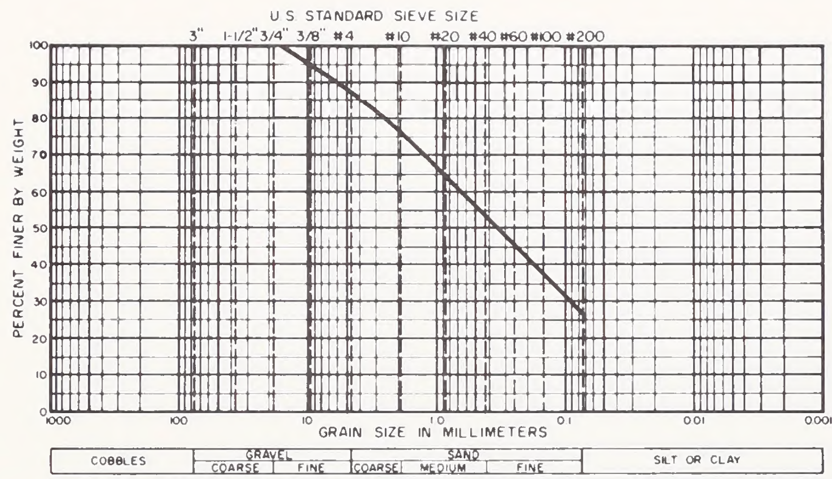
APPR./REV. BY	DATE	ORIGINATOR JFW	DATE 11/82
DRAWING NUMBER	SCALE	REVISION NUMBER	SHEET OF

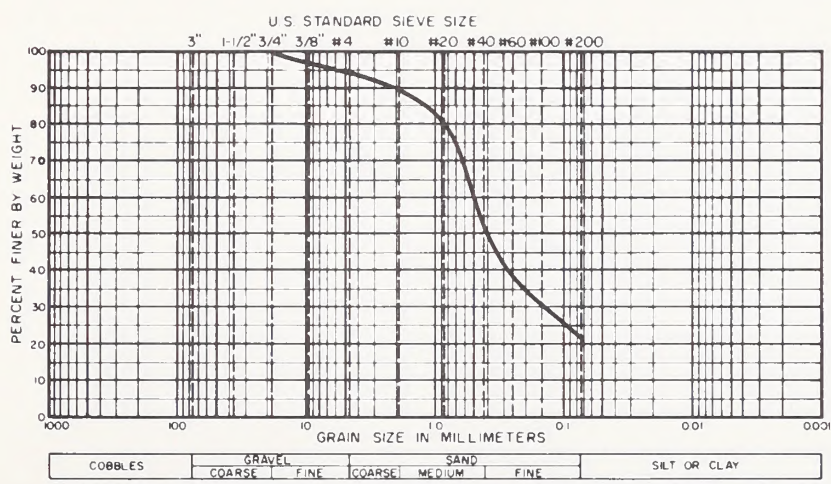
PLATE 6A



LOCATION	DEPTH	CLASSIFICATION
BORING A-3	**9 1/2-10ft.**	**SM**



LOCATION	DEPTH	CLASSIFICATION
BORING A-3	**19 1/2-20ft.**	**SM**



LOCATION	DEPTH	CLASSIFICATION
BORING J-1	**4 1/2-5ft.**	**SM**

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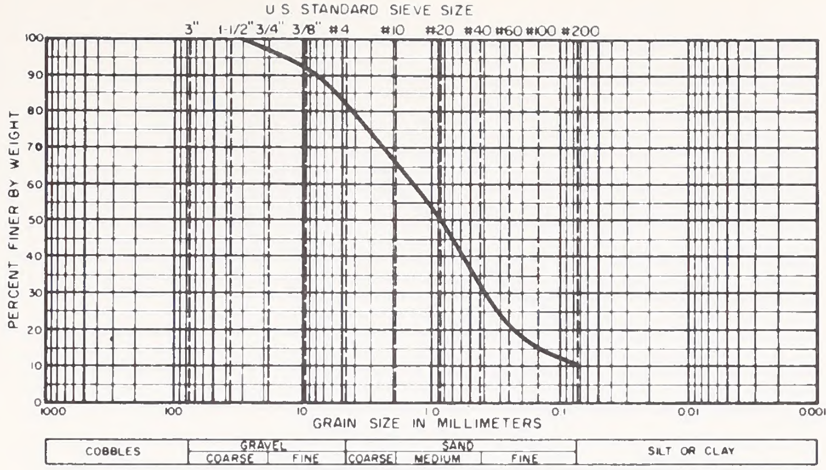
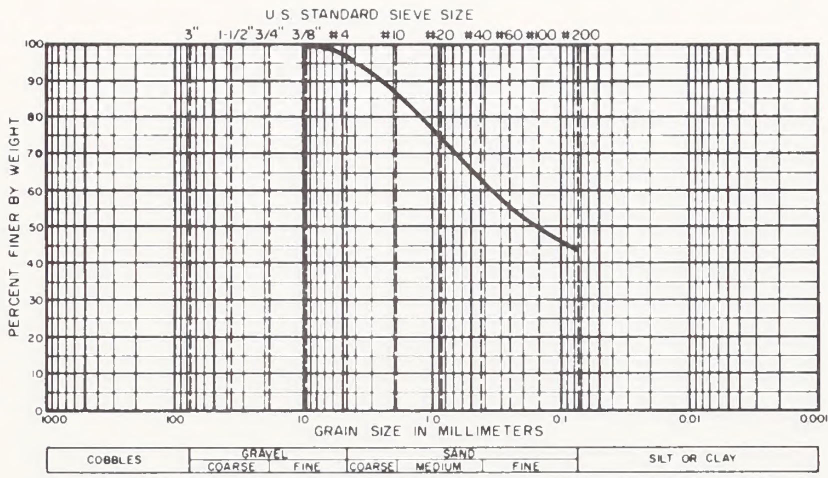
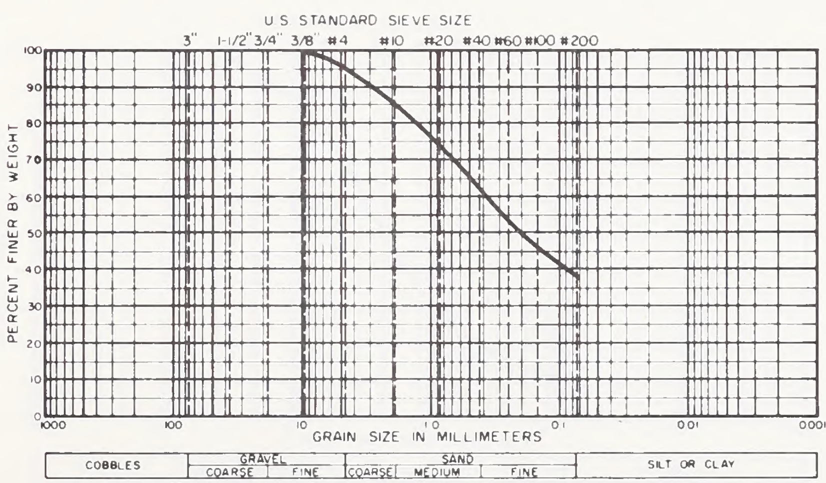
PLATE 6B



LOCATION	DEPTH	CLASSIFICATION
BORING J-3	5 1/2-6ft.	SM



LOCATION	DEPTH	CLASSIFICATION
BORING J-4	5 1/2-6ft.	SM-ML



LOCATION	DEPTH	CLASSIFICATION
BORING J-4	15-15 1/2ft.	SC

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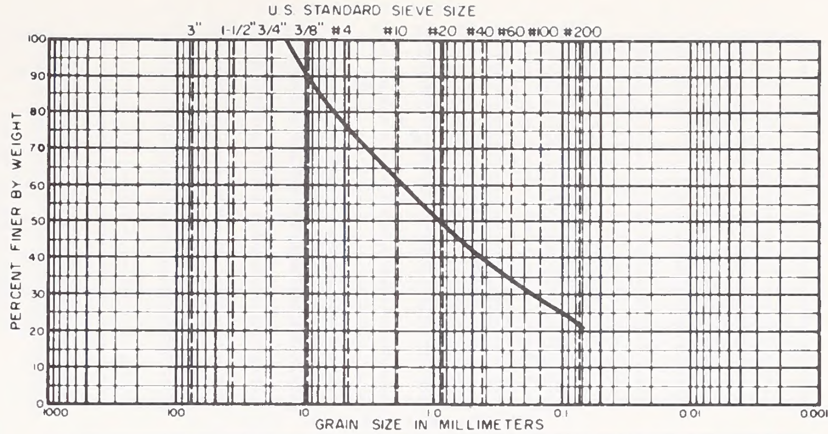
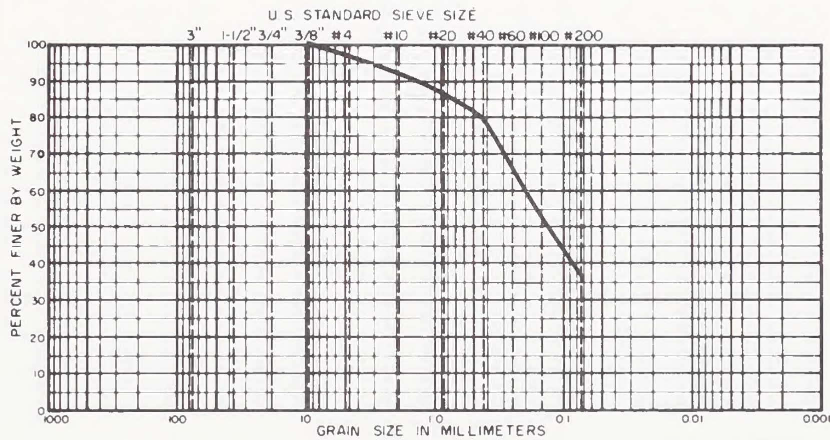
PLATE 6C



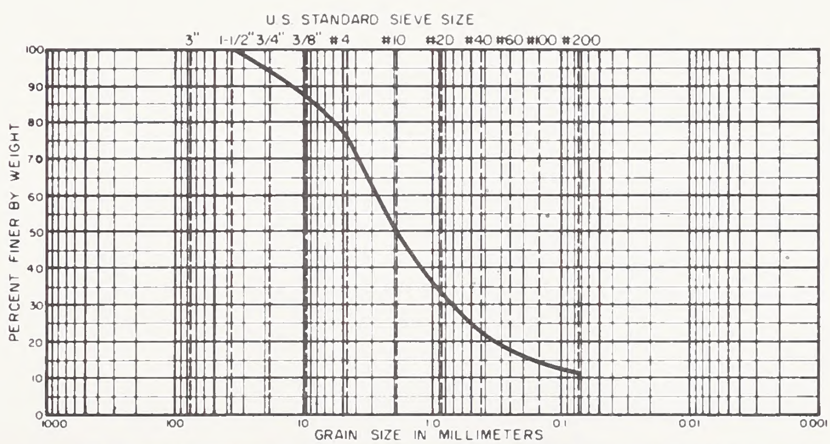
COBBLES	GRAVEL COARSE	GRAVEL FINE	SAND COARSE	SAND MEDIUM	SAND FINE	SILT OR CLAY

LOCATION	DEPTH	CLASSIFICATION
TEST PIT A-1	**8ft.**	**SM**



COBBLES	GRAVEL COARSE	GRAVEL FINE	SAND COARSE	SAND MEDIUM	SAND FINE	SILT OR CLAY

LOCATION	DEPTH	CLASSIFICATION
TEST PIT J-1	**1-2ft.**	**SM**



COBBLES	GRAVEL COARSE	GRAVEL FINE	SAND COARSE	SAND MEDIUM	SAND FINE	SILT OR CLAY

LOCATION	DEPTH	CLASSIFICATION
TEST PIT J-1	**4-6ft.**	**SP-SM**

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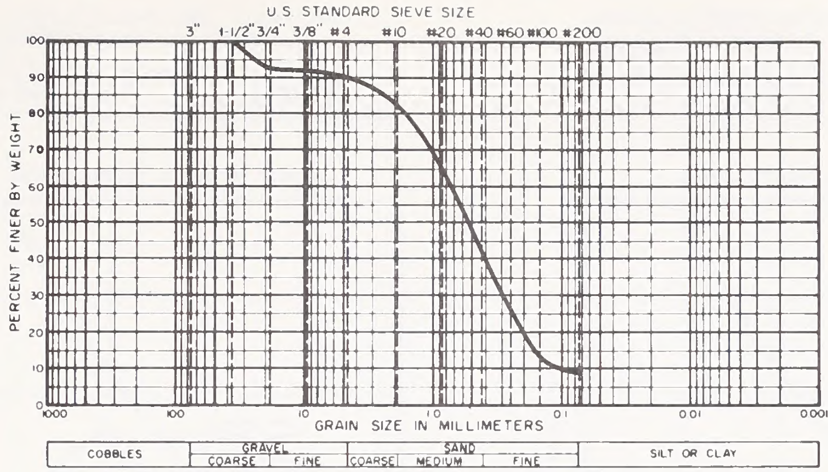
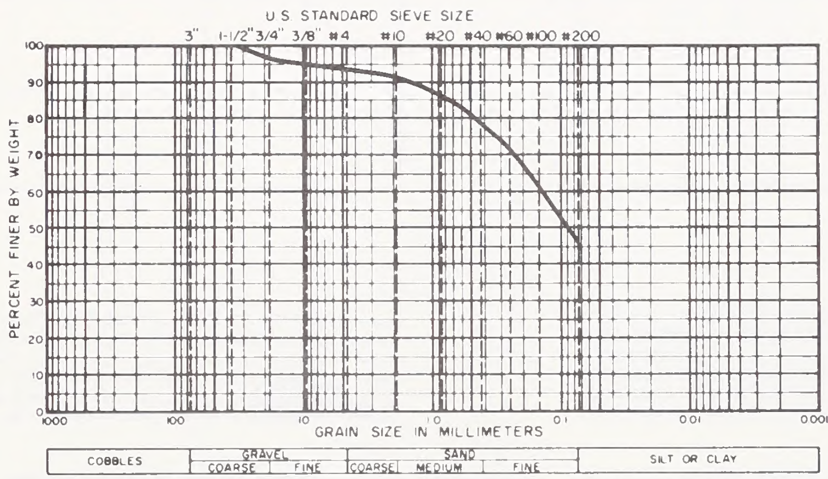
PLATE 6D



LOCATION	DEPTH	CLASSIFICATION
TEST PIT J-2	**6-8ft.**	**SP**



LOCATION	DEPTH	CLASSIFICATION
TEST PIT J-3	**6-8ft.**	**SM-ML**

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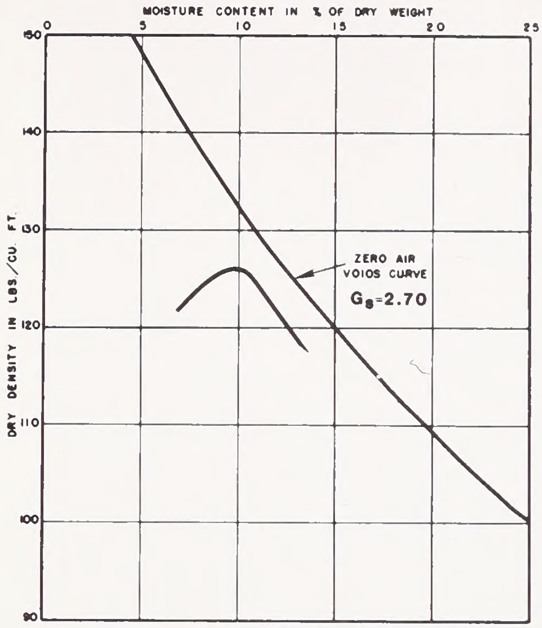
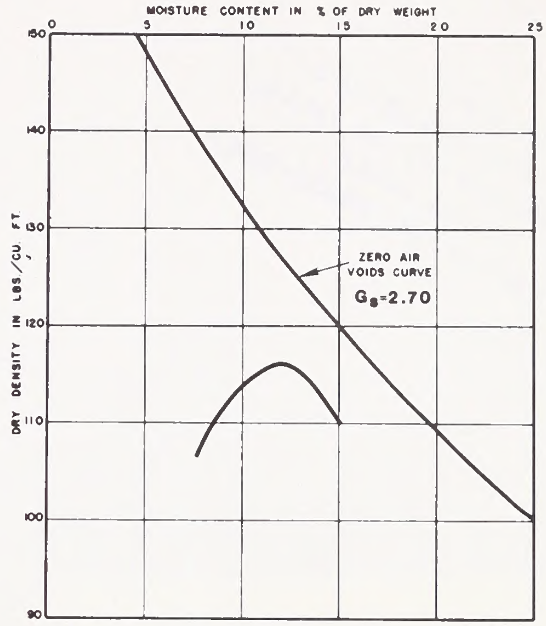
PLATE 6E

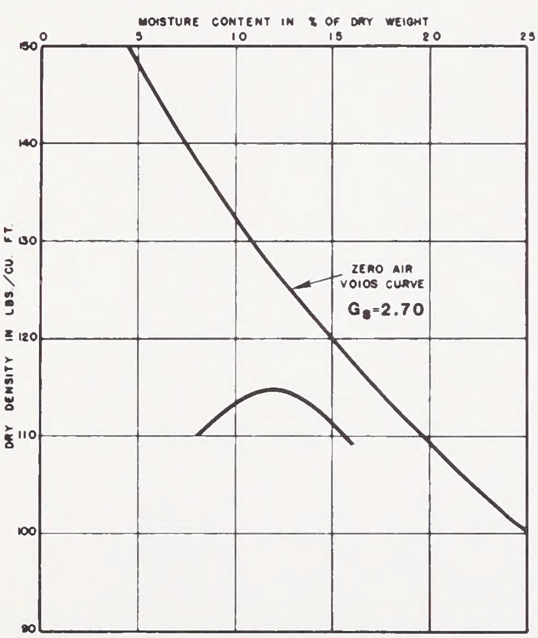
SAMPLE NO. TP-A-1 DEPTH 8ft. ELEVATION
SOIL BROWN SILTY F-M SAND & F-C GRAVEL
LOCATION
OPTIMUM MOISTURE CONTENT 10.0%
MAXIMUM DRY DENSITY 126.0 PCF
METHOD OF COMPACTION ASTM D-1557 METHOD C



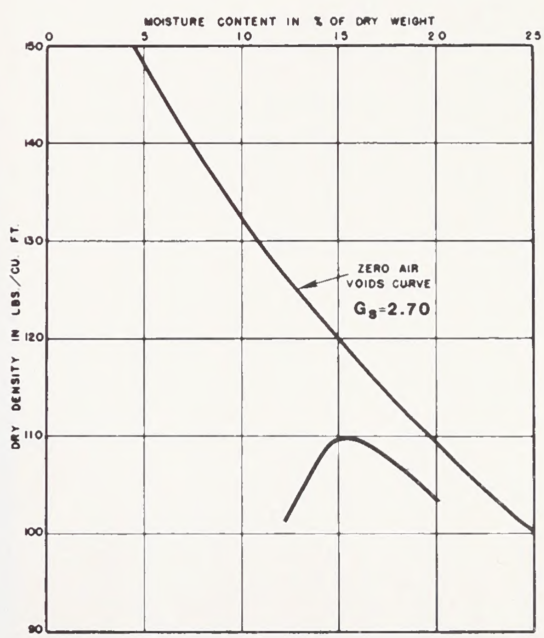
SAMPLE NO. TP-J-1 DEPTH 4-6ft. ELEVATION
SOIL LT. BROWN F-C SAND W/LITTLE CLAYEY SILT & F-C GRAVEL
LOCATION
OPTIMUM MOISTURE CONTENT 12.0%
MAXIMUM DRY DENSITY 116.0 PCF
METHOD OF COMPACTION ASTM D-698 METHOD C



SAMPLE NO. TP-J-2 DEPTH 6-8ft. ELEVATION
SOIL BROWN F-C SAND W/LITTLE F-C GRAVEL & SILT
LOCATION
OPTIMUM MOISTURE CONTENT 12.7%
MAXIMUM DRY DENSITY 115.0 PCF
METHOD OF COMPACTION ASTM D-698 METHOD C



SAMPLE NO. TP-J-3 DEPTH 6-8ft. ELEVATION
SOIL BROWN F-M SAND & SILT W/TRACE CLAY
LOCATION
OPTIMUM MOISTURE CONTENT 15.2%
MAXIMUM DRY DENSITY 110.2 PCF
METHOD OF COMPACTION ASTM D-698 METHOD C



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TITLE
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SCALE

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